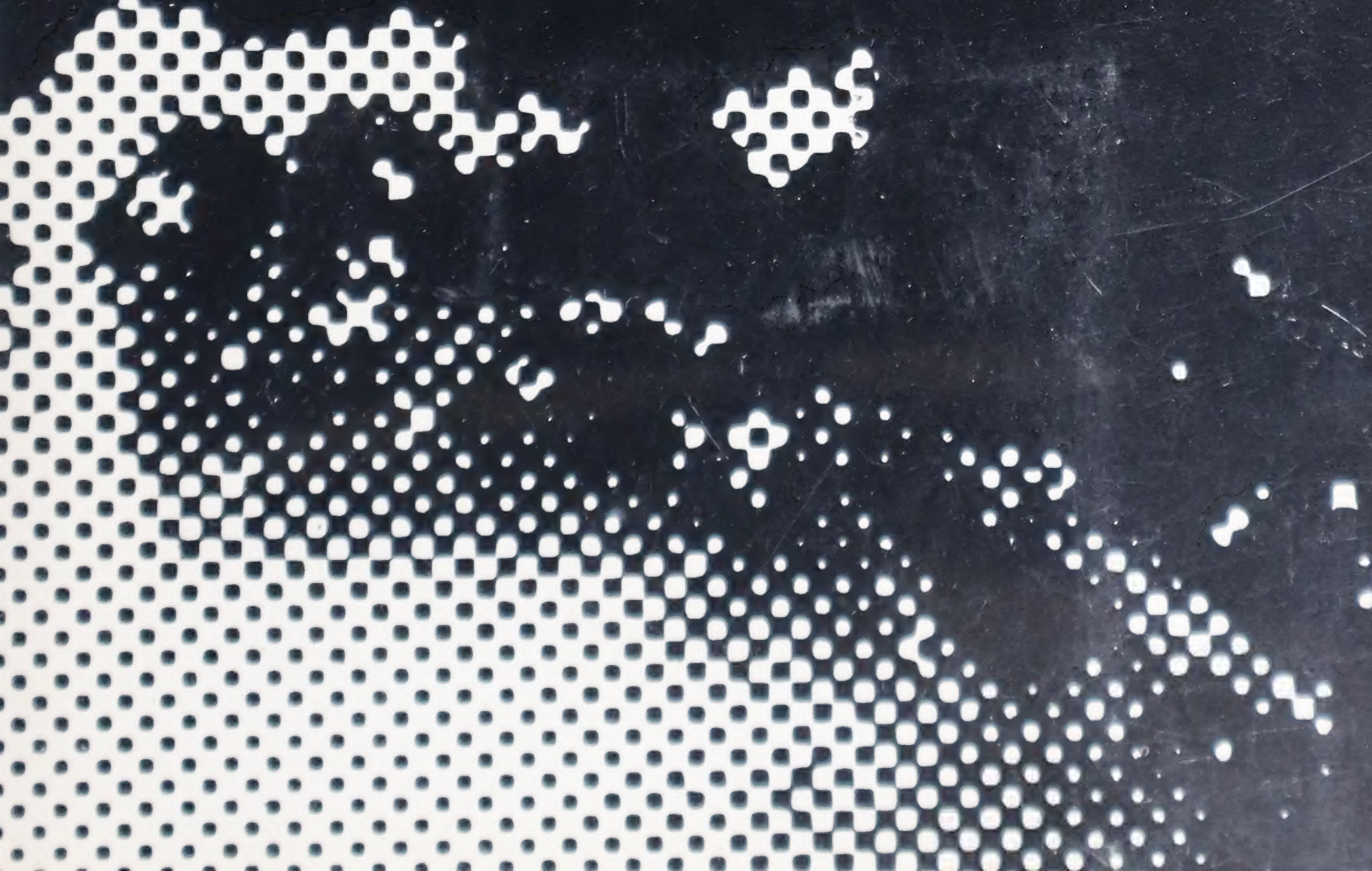
outer limits and human needs

Edited by William H Matthews

Resource and Environmental Issues of Development Strategies



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Outer Limits and Human Needs

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Another Development: Approaches and Strategies

Outer Limits and Human Needs

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Edited by William H Matthews

The Dag Hammarskjöld Foundation
Uppsala 1976

The Dag Hammarskjöld Foundation was established in 1962 in memory of the late Secretary-General of the United Nations. The views expressed in its publications are entirely those of the authors and do not necessarily reflect those of the foundation.

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Contents

Preface

In July 1975, a special double issue of *Development Dialogue*, the journal of the Dag Hammarskjöld Foundation, was published under the title *What Now: Another Development* (English edition), *Que Faire: Un Autre Développement* (French edition) and *Qué Hacer: Otro Desarrollo* (Spanish edition). In addition, a German edition (*Was Tun*) was published by the Vienna Institute for Development. The publication and world-wide distribution of this report, which was prepared as an independent contribution to the Seventh Special Session of the United Nations General Assembly, comprised the first phase of the 1975 Dag Hammarskjöld Project on Development and International Cooperation. In the process of developing the report, thirty-three basic and discussion papers were prepared. This book contains three of these papers and a fourth which encompasses many of the issues that permeated the discussions leading to the report.

Though many factors contributed to the decision to launch the 1975 Dag Hammarskjöld Project, the most significant one was the proposal by Maurice F Strong, as Executive Director of the United Nations Environment Programme (UNEP), to launch an inquiry into the means of satisfying basic human needs without transgressing the outer limits of the biosphere. Marc Nerfin, as a consultant to UNEP, prepared a feasibility study on the proposed inquiry. His report led to the decision by the Dag Hammarskjöld Foundation to assume the responsibility for the project, and Marc Nerfin was asked to serve as its Director. Financial support was given by UNEP, the Swedish International Development Authority (SIDA) and the Dutch Ministry for Development Cooperation.

The 1975 Dag Hammarskjöld Report has to date been printed in 42,000 copies in the four language editions. Since it was first published, there has been a constant demand for the background papers on which the report is based. Only parts or elements of these papers have so far been published, for instance in *Ceres* (No. 50), the journal of the FAO, in *2000* (No. 34), the French journal of futurology and in *Social Science Information*, published under the auspices of the International Social Science Council by the Maison des Sciences de l'Homme (Paris).

The present volume, *Outer Limits and Human Needs,* is the first of several publications which the foundation intends to issue in order to make the material gathered for the project more generally available. It has been edited by Professor William H Matthews in such a way that it provides the basic concepts needed for purposes of analysis and links these concepts to the practical problems of ecodevelopment.

A second volume, entitled *Another Development: Approaches and Strategies,* is being edited by Marc Nerfin for publication in the near future. It consists of ten papers and contains both elements of a conceptual approach to 'another development' and a series of case studies of national experiences and strategies. In addition, the foundation is continuing to pursue its inquiries into alternative development models in the fields of education and health. The results of this work are expected to be published during the coming year.

Uppsala, June 1976

Sven Hamrell
Executive Director
The Dag Hammarskjöld Foundation

Introduction

The papers assembled in this volume address some of the issues originally raised by Maurice F Strong when, as Executive Director of the United Nations Environment Programme (UNEP), he posed the question, 'Can we meet basic human needs without transgressing resource and environmental outer limits?' This question seems to contain the fundamental elements of supply, demand and sustainability that pervade —usually implicitly—most debates on limits.

The only short answer to this question is that 'it all depends'. The real questions revolve around what it depends upon. First, one might ask what the question means. Does the word 'can' imply ability or willingness? Who are the 'we' who will meet the needs—those that have them or those that have the resources to do it? Whose needs will be met? Who will define the needs—those that perceive them and/or those that must meet them? Will the needs vary among individuals and/or societies? What is meant by 'basic' and 'human' and how much are they culturally rather than physiologically determined? What constitutes 'transgression'? Why add such a constraint and not others? Whose resources and what environmental systems? How much depletion, degradation or stress is acceptable? What is really meant by the term 'outer limits' and can the natural scientists tell us what they are? And so on.

The three fundamental conceptual issues to explore are basic human needs, outer limits, and development strategies that balance concern about both of these. The papers in this volume address the latter two issues directly and the first one indirectly. Other papers and panel reports prepared for the 1975 Dag Hammarskjöld Project that are more directly concerned with the subject of 'basic human needs' will be published in the near future.

This volume is divided into three sections: Grappling with the Conceptual Problem (one paper), Ecosystems and Development (two papers) and Developing the Methodology (one paper). These four papers combine to present a variety of conceptual issues with specific examples of the types of situations which are often encountered in development planning.

The first paper, 'The Concept of Outer Limits', was prepared by Dr William H Matthews, then Arthur D Little Associate Professor of Envir-

onmental Sciences and Engineering at the Massachusetts Institute of Technology. At the outset of the project it was generally assumed that the question of resource and environmental outer limits was the most straightforward, though by no means simple, part of the exercise. However, further consideration suggested that outer limits are not wholly based on firm (albeit poorly understood) physical and biological conditions and laws. In fact, the paper argues, physical and natural scientists can make little progress in determining resource and environmental limits without a very sophisticated understanding of numerous societal and political processes.

The paper further suggests that with respect to development strategies the context of the limit—local, regional or global—must be explicitly considered and the trade-offs among environmental and other objectives must be analysed. These dimensions can only be treated if the planning and decision-making processes combine scientific, economic, societal and political factors at every stage. A conceptual framework is suggested for such processes.

The two papers in the second section elaborate the implications for development planning that arise from a thorough assessment of resource and environmental potentials and constraints. The first paper is by Professor Ignacy Sachs, Director of the International Research Center on Environment and Development (CIRED) of the École des Hautes Études en Sciences Sociales of the University of Paris. This paper was prepared by Professor Sachs prior to the commencement of the 1975 Dag Hammarskjöld Project and the ideas developed in it were very influential in the preparation of *What Now*.

In his paper, Professor Sachs introduces the concept of ecodevelopment, that is, 'a style of development which, in each ecoregion, calls for specific solutions to the particular problems of the region in the light of cultural as well as ecological data and long-term as well as immediate needs. Accordingly it operates with criteria of progress which are related to each particular case, and adaptation to the environment, as postulated by the anthropologists, plays an important part.' In the context of this volume, ecodevelopment attempts to meet basic human needs in ways

that can be sustained because outer limits are not transgressed. The paper provides definitions, guidelines and principles for ecodevelopment and outlines several examples to illustrate the scope of application of ecodevelopment strategies.

The second paper in the second section is by Dr M Taghi Farvar, then Director of the Centre for Endogenous Development Studies in Teheran, now Vice-Chancellor for Environmental Sciences and Ecodevelopment at the Bu-Ali Sina University, Hamadan, Iran. In it, Dr Farvar has drawn heavily on his extensive experience with development strategies and techniques for agricultural production and for public health to provide some specific examples of how poorly conceived approaches have resulted in 'net underdevelopment' as judged by the criteria of meeting basic human needs. The major conclusion of this paper, as of the one preceding it, is that a new approach to development—which may be termed ecodevelopment or an ecosocietal or redistributive-environmental approach—must be made if basic human needs are to be met in a sustainable manner.

As Professor Sachs notes near the end of his paper: 'The concept of ecodevelopment is intended to be operational . . . . The application of the concept does, however, require a sustained research effort accompanied by pilot activities subject to critical review, so that permanent feedback is established between practice and action-oriented research.' The final paper in the volume outlines a methodological approach for making some of these ideas more operational. The methodology and example were prepared by Joseph C Perkowski, a doctoral candidate in environmental systems management at the Massachusetts Institute of Technology.

Mr Perkowski begins where the first paper in this volume ends —with the conceptual framework and the list of technical considerations involved in determining where 'outer limits' are in the context of a particular development strategy. Through the example of energy production, he illustrates some of the complexities encountered in addressing the challenges of ecodevelopment in a systematic way. This is a first, but important step, in determining what level of analysis, what types of data and what types of societal and political decisions will be required in all sectors if governments are to adopt the principles of ecodevelopment.

The question that motivated the development of the papers in this volume was, 'Can we meet basic human needs without transgressing outer limits?' In trying to answer it, the various authors have each discovered in their own way and from their own perspectives other sets of questions which must be addressed before the original one can be answered. Yet while we have seemingly made the subject more complex we feel that we have made some progress in illuminating the nature of the issues that the peoples of the world must address as they make the fundamental choices that will determine whether or not their particular goals and approaches for development result in meeting their basic needs in a sustainable manner.

William H Matthews

1 Grappling with the Conceptual Problem

The Concept of Outer Limits

by William H Matthews

Introduction

When the phrase 'outer limits' was first coined a few years ago, it was generally used in a global context to suggest the fragileness of major planetary life-support systems and processes in much the same way that the concept of 'spaceship earth' suggested the finiteness and 'only one earth' suggested the uniqueness of the planet on which man is totally dependent for his survival. It is a powerful and very evocative phrase and it quickly entered the vocabulary of those concerned with global environmental quality.

One of the most often cited examples of an outer limit has been the very small range of global temperature shift (possibly as little as ±2°C) that might result in an irreversible melting of the ice caps or the beginning of a new ice age. Other examples cite calculations of how long resources such as oil may last. Perhaps as a result of such examples many people seem to have begun viewing outer limits as very definite limits—set firmly by nature and theoretically determinable by man—that once over-reached would result in some major ecological catastrophe of world-wide scope. While such a model is realistic in a very general sense, to view outer limits in this way is to look at only part of what the concept is really about—and perhaps not the most important part with respect to how man must learn to manage his affairs to meet his needs and to prevent catastrophes.

The first section of this paper will suggest that there are two basic determinants of outer limits and that both must be considered in arriving at some 'scientific' definition of what and where the limits are. These determinants are: (1) the quantity of existing resources and the laws of nature; and (2) the way man conducts his activities with respect to this natural situation. This assertion has major implications for how outer limits are perceived, defined and, hopefully, respected.

The second section expands the concept so that it includes more than global limits. 'Outer' had been used initially with respect to the planet in much the same way as the term 'outer space'. However, limits can be 'outer' with respect to a variety of geographical or political considerations. The outer limits of a lake as a viable ecosystem or of available resources within a country can have profound consequences for those

involved even though they do not threaten life or activities at a planetary level. This expanded concept has significant implications for issues such as independence, dependence and interdependence.

The next section discusses the elaboration and further development of the concept that is required when it is used in the phrase 'meeting basic human needs without transgressing outer limits'. Applying such a constraint to the objective of meeting basic human needs implies profound value judgements on societal priorities. These must be made very explicit if analyses in this area are to be considered seriously and wisely by persons who have the responsibility for making such value judgements.

Once the issues and questions that must be addressed in fully developing the concept of outer limits have been discussed, some of the points to be considered in the development of approaches to determining some types of outer limits will be outlined. These suggestions are intended to illustrate the complexity of determining outer limits both in scientific and in societal senses. Much more thought and experimentation would be required to develop a variety of truly operational approaches.

Determining outer limits does not, as some people may have thought, simply involve scientific assessments of the 'depletion point' or 'breaking point' of the earth's various resources and environmental systems. The concept is much more complex and includes some consideration of how basic societal values are selected and implemented. Application of this concept in the context of meeting basic human needs expands it even further with respect to the types of values that must be addressed in complex social and political processes. The objectives of this paper are to identify some of these non-scientific dimensions of outer limits as well as the scientific aspects; to move on a few more steps in the development of the concept; and to make some initial suggestions of approaches to operationalize the concept in the context of meeting basic human needs.

Determinants of outer limits

In this section we will, primarily, explore the nature of the 'limits' referred to in the concept and then (in the following section) address the meanings of 'outer'. The limits are not, in all cases—nor even in most

cases—explicit, predictable, discrete thresholds which if exceeded produce catastrophic results, regardless of how they are approached. The mental image should not be that of the edge of a cliff where a single additional step plunges one to the depths below. The concept is much more complex and requires full consideration of the role man plays in setting the limits, since these are determined in two ways: (a) by the quantity of existing resources and the laws of nature; but also, (b) by the way man conducts his activities with respect to this natural situation.

The fact that man as well as nature actually determines where the limits are suggests hope for the future because while we cannot change the laws of nature it is theoretically possible to change some of the activities of man and thus influence the limits themselves. This assertion does not suggest that man can add more resources to the planet or that he can technologically alter the basic regulatory mechanisms of natural systems. It is instead based on the fact that the degree of flexibility, resiliency and self-generation in many of these systems is such that man can, by the timing and conduct of his activities, extend the limit if he conducts his affairs in a different way.

Concern about outer limits generally focuses on resources—both non-renewable and renewable—and on environmental systems. Non-renewable resources are those which, once used, are not replacable by nature or man except perhaps over geological time; for example, oil, bauxite and copper ore. While it is certainly true that there is a finite limit on the actual number of molecules of a given resource in the earth's crust or core, the practical limits to exploiting that potential are a function of man's activities. Conversion of a theoretical resource into a usable 'reserve' is a complicated function of scientific (usually geological or metallurgical) knowledge, technological capability and economic priorities. Economic factors are directly related to societal and political processes of choice selection and decision-making and technological capability is often dependent on societal priorities for investment of limited professional and financial resources for research and development. For example, the amount of available copper increases dramatically if one develops the technologies and is willing to pay the price for using ores of

progressively lower grade and possibly for ultimately extracting copper from sea-water.

Renewable resources are those which under certain circumstances will replace themselves or can be replaced by man; for example, trees, soil fertility and fish populations. Environmental systems and their components are much more complex and difficult to define. There are many ways to categorize them but all are rather arbitrary and none is very satisfactory because a simple listing cannot account for the complexity and interrelatedness of all the parts of the 'environment' (for example, air 'sheds', water bodies, climate systems and genetic resources). There are a multitude of ways outer limits could be reached in environmental systems; for example, the entire climate could be altered or perhaps only one atmospheric component such as ozone might be reduced; an entire ecosystem such as a lake or an ocean might be 'destroyed' or only one animal species within that ecosystem might become extinct.

An analogy might be helpful in demonstrating how man as well as nature determines where the limits are. The human body is a complex combination of thousands of components and interrelated systems and as such is analogous to an ecosystem or even the biosphere as a whole. We know that a person can die from physical over-exertion and that climbing stairs requires physical exertion, but it is hardly reasonable to expect an answer to the simple question: how many stairs can a person climb before he dies (reaches his 'outer limits') and what would be the cause (for example, exhaustion, cardiac arrest, respiratory failure, ruptured arteries, stroke, etc.)?

Even if we had a complete understanding of how the body works, of the state of this particular person's body and numerous case studies of persons in a similar state dying climbing stairs, the question still could not be answered. The person's 'outer limit' of stair climbing is not only a function of the state of his body but it is also a function of how he climbs the stairs. If he runs up them as fast as possible until he dies he can probably climb far fewer stairs than if he walks up them at a very slow pace. Furthermore, if he climbs stairs the way most of us do—only whenever he must in the course of his daily life—the question is almost totally

irrelevant, for while he may climb millions of stairs during his lifetime he is not likely to die on a staircase or as a direct result of all that activity.

Two hundred stairs might 'kill' him and two million might not. Note that although this example assumed complete scientific understanding and precedents the outer limit could still not be predicted without a detailed description of how the person would act. The outer limit is a function of both his body and the way he treats his body. The same situation is true for non-renewable resources and environmental systems and the way man treats them.

This appreciation has major implications for methods used to determine outer limits. If one assumes that the limits are intrinsic in nature, then the prescription would be to get many scientists together and have them carry out research and perform experiments and gather enough scientific knowledge and data together to predict the limit of some resource or system. It is hoped that the human analogy given above demonstrates that the scientists would, under the very best of circumstances of complete knowledge, have only some of the data needed for the determination of outer limits. This scientific information would have to be coupled with an exact description of the way man would be operating with respect to the resource or system, in order to determine where the limit would be *and* whether it might be exceeded under those circumstances. Thus the scientists, while essential, cannot really provide definitive help unless they know what one is trying to do and how one is going about it. The methodology for determining outer limits must take this fully into account, as will be discussed in later sections.

The realization that man plays a role in many cases in determining where outer limits are, places a further responsibility on man with respect to his utilization and management of renewable resources and environmental systems. Since he can have a part in setting them as well as deciding if they will be exceeded, he has much more 'control' than one might have at first thought. One very serious question is how he will use his knowledge of the flexibility of much of the biosphere (a knowledge which is itself limited in nature and degree) in the development of policies for regulating his activities.

Will man operate in such a way that the limit is never really an issue, like the person slowly walking up stairs only when they are encountered? Or will he use his scientific knowledge to allow him to push the resources or systems as hard as he can without bringing the limits below the immediate demands of his activities? This would be like the person who, knowing that at full speed his heart would probably burst if he ran up the 1,000 steps he wishes to climb for some reason, makes a practice of climbing the 1,000 steps on a regular basis by running up 800 and walking up the remaining 200. He is clearly setting the outer limit of death at a relatively low number of steps—somewhat over 1,000 but probably tens of thousands less than the person who does not climb 1,000 steps at a time or who at least walks up them.

Deliberately acting in such a way that the outer limits are set low and then pushing very close to them could lead to catastrophic results, because man is interacting with systems that he barely understands. The chances of being wrong in his 'calculations' are very large and the risks are very great. The way man views these risks to the 'environment' and to himself and the way he trades them against the benefits of his activities is a function of values and priorities. Some of the implications of these trade-offs will be discussed in later sections.

Global and non-global outer limits

The phrase 'outer limits' has often been used in reference to biophysical conditions essential to the survival and well-being of the human species. In that context they have referred to situations that were global in scope and sombrely profound in their implications. Often-cited examples include major climate changes, 'death' of the oceans, depletion of global oil reserves, destruction of the stratospheric ozone layer, reduction in planetary oxygen, desertification of continents, and even the wide-scale destruction of thermonuclear war. The occurrence of any of these would have drastic and far-reaching implications for life on this planet as we know it today.

There has been some ambiguity in the way the word 'outer' is interpreted in the phrase outer limits. Since there have not been explicit,

widely circulated discussions of the concept of outer limits or of methodologies for determining them, it is not clear what interpretation is 'correct'. Correctness is a matter of definition, so the following discussion will first describe what 'outer' does not mean in this paper and then what it does mean. Other interpretations are, of course, valid but the rest of the development in this paper is dependent on the following definition. Clarifying this interpretation is essential before further development of this concept.

For our purposes, 'outer' does not mean the furthermost point to which something can be stretched before breaking. An example of this interpretation would be to refer to global temperature variation of ±2°C as the 'outer' limits of variation beyond which a major climatic change might occur. Any variation between −2°C and +2°C would not be far enough 'out' to be an 'outer' limit.

In this paper, the word 'limit' when used in the phrase 'outer limit' refers to the ±2°C-type variation. If it is within these 'limits' then it would not be labelled as an 'outer limit'. In other words, the word 'outer' is not used to define 'limit' in the way a word like 'upper' or 'lower' might be used. The 'limit' is the furthermost point to which something can be stretched before breaking.

The modifier 'outer' is used to give the *context* of the limit. One is not asking how far 'out' a limit is before it is considered 'outer'; one is instead using the word 'outer' to define the boundaries of some frame of reference within which the 'limit' has some meaning. For example, in the global context the modifier 'outer' suggests that only 'limits' of global importance be considered, such as climate or oceans, as distinct from local weather patterns or lakes. The latter are not global and thus limits on their viability (and there certainly are some) would not be considered outer limits in a planetary sense. If the other interpretation of 'outer' were used, the outer limit of a lake's viability would have a meaning such as eg that eutrophication would occur if x tons of phosphorus were put in at rate y. This interpretation would not have anything to do with the context (for example, global or regional) but only with determinants of the outer limits discussed in the previous section.

Such a lengthy discussion of definitions may seem overly pedantic, but the further development of the concept of outer limits in this and the next section requires some precision and explicit agreement on definitions. Using the word 'outer' to denote a context rather than a numerical determination has important implications for this development.

As noted at the beginning of this section, the phrase 'outer limits' has generally been used in a global context where 'outer' has been used to denote those limits which if exceeded would result in ecological catastrophes of a global nature, perhaps with implications for human survival. It is possible to choose other contexts and then to use the word 'outer' to denote their boundaries. For example, one could speak of the 'outer limits' of the resources of a certain country and define the context in a geopolitical way rather than in a global sense. These 'national' outer limits might not have any relation to 'global' outer limits; for example, the 'national' outer limit of coal may be x tons and the 'global' outer limit of coal might be 1 million times x tons. But if the country only has access to its own coal then the 'national' outer limit is just as profound to the survival of the country as the 'global' outer limit is to the survival of the human species. Indeed, in a practical sense the national limit is probably the more relevant one because of the political realities implicit in the control and allocation of resources.

From this point on, when the context of the phrase 'outer limits' is relevant to the discussion, an appropriate modifier will be given; for example, global outer limits, regional outer limits or national outer limits. The quotation marks introduced above for emphasis will be discontinued.

If the concept of outer limits is thus deepened to refer to more than the global frame of reference, one can begin to use it to analyse the types of limits that may be encountered by governments at various levels in their attempt to meet needs and stay within the biophysical constraints that are placed upon them by geographical and political boundaries. Then this powerful and evocative concept could be related in a variety of meaningful ways and at several distinct levels to governmental and societal planning and decision-making. Some of the most interesting aspects of

applying this broadened concept are the implications for national and regional independence, dependence and interdependence.

The context in which outer limits are considered is very important because it identifies many of the scientific, value and decision-making aspects in analyses needed for efforts to meet goals such as 'meeting basic human needs without transgressing outer limits'. Some of the value and decision-making aspects will be discussed in the next section and the scientific aspects in the section after that. Here some indication will be given of the way the nature of the basic problem to be addressed is influenced by the context in which outer limits are considered. It is hoped that this will demonstrate why the distinctions discussed above have been so carefully developed.

There are several very important differences in the aspirations to 'meet basic human needs without transgressing global outer limits' and to meet them 'without transgressing national outer limits'. The most fundamental selection of the parameters to be considered in the analysis and strategy formulation for each of these goals is qualitatively and quantitatively different. Furthermore the differences in problem definition can be even more pronounced if one aspires 'to meet basic human needs' (the context of these must also be given but that is beyond the scope of this paper) without transgressing eg Western European or Soviet bloc or OECD or OPEC or East African or the Group of 77 (or 97) outer limits. The context in which outer limits are considered determines the resource base, the types of environmental systems, the mixes of societal values, the political structures, the international and intercultural aspects and many other parameters that one needs to define the basic problem and that ultimately would be involved in the formulation of development strategies.

The previous section pointed out that many (though not all) outer limits are determined by both nature and man. The more societal and political units that are combined in the context, the more difficult a definition of outer limits becomes and the more difficult it is ultimately to prescribe viable strategies for determining, making and implementing the trade-offs that will surely arise between meeting certain needs and not trans-

gressing certain outer limits. It is essential that this difficulty is not compounded by an ambiguous statement of the goal to be sought.

A single illustration is probably sufficient to show how radically different perceptions of problems can be, depending upon the context. If one is concerned about global outer limits of the viability of the human species then any activity that ultimately resulted in a loss of one hundredth of 1 per cent of the planet's population would not be considered terribly significant. But if one is concerned with local or national outer limits of population or urban viability and that particular loss of 400,000 persons was from one country, perhaps in a single age group or single urban area, then the country might conclude that very serious outer limits would be transgressed even though the loss would be insignificant if one only considered global outer limits. Clearly any analysis of outer limits must reflect these differences.

The consideration of various non-global outer limits in addition to global outer limits has important implications for the types of analyses that might be undertaken by developing countries as contrasted to developed countries. This is especially true when issues of 'self-reliance', 'regional viability', 'independence' and 'selective interdependence' are being raised. If one assumed that the only goal were not to transgress global outer limits then the major emphasis in the short term would be on the developed countries, for they are primarily the ones which are at present living well beyond their national outer limits for many resources and are placing major demands on the global outer limits of critical environmental systems and components. In the longer term, the aspirations of developing countries would also have to be weighed against these global outer limits and some adjustments would inevitably have to be made. This type of global view has gained wide visibility through studies such as *The Limits to Growth*, carried out for the Club of Rome.

In such a global case the strategies of any country would always be evaluated in terms of global resources and global systems as though there were some huge common basket from and into which people could extract materials or dump wastes. Unless very careful book-keeping of present and future demands were undertaken the aggregation of all these

extractions and impacts could very well result in a global 'tragedy of the commons' before the problem was even clearly perceived. Needless to say, any attempts at regulation or rationing at the global level meet with formidable obstacles.

On the other hand, if the outer limits concept is broadened to include non-global outer limits, such as the resource base of a country or the river systems upon which a country depends for drinking water, irrigation and fish, then the types of analyses that must be performed are very different from those for the more profound, but also more esoteric and more distant, global outer limits. Furthermore, the loss of a country's resources or environmental support systems may be even more significant to that country than the transgression of some global outer limit that the rest of the world considers very significant.

The complexity, richness and ultimate usefulness of analyses can also be increased by choosing the context of outer limits on the basis of specific resources or environmental systems and by mixing strategies in terms of what will not be (or will be) transgressed in what context. For example, in meeting a specific set of needs a country might conclude that it will be aware of any tendency to transgress the following outer limits in their respective contexts (and will be prepared to transgress them in other contexts): Western European outer limit for coal, OECD outer limit for food, national outer limit for soil fertility, city outer limit for massive deaths, personal outer limit for cancer, global outer limit for climate, adjacent country outer limit for oceans, multilateral treaty organization outer limit for a fish population, and so on. The choices of context may be based on any combination of scientific, technical, social, political, economic and other grounds.

The need for such specific breakdowns both in terms of analysis and in terms of ultimate decision-making should be apparent. The difficulty of doing the analyses—identifying the areas of conflict and the actors involved—and of developing and using a wide variety of decision-making processes should be equally apparent. Before suggesting a first step in developing an approach to tackling some of these analytical problems and in illustrating it (as in Part 3 of this volume), it is necessary to

develop the concept of outer limits even further. While this will add more layers of complexity, it may be hoped that this will move us closer to a fuller understanding of what is really involved when one aspires not to transgress outer limits and looks for analytical techniques to determine when this might happen.

Outer limits and 'meeting basic human needs'

In the previous section, it was shown that the concept of outer limits must be broadened with respect to a variety of geopolitical contexts when viewed from the perspective of the goal of 'meeting basic human needs without transgressing outer limits'. In this section some of the other implications of this goal for the concept of outer limits will be explored. These implications are primarily related to the types of fundamental value judgements that must be made on societal priorities if a full analysis of outer limits is to have operational significance.

In examining the goal as worded one might well ask why there is the explicit constraint of not transgressing outer limits. One could certainly argue that there are other important, and perhaps to some even more important, constraints one might make an explicit part of the goal; for example, meeting basic human needs without jeopardizing national security, or without violating personal liberty, or without causing runaway inflation, or without upsetting the balance of payments, or without disrupting constitutional processes, or without reducing the economic growth rate below *x* per cent per year, and so on. To respond to these questions, the advocate for the outer limits clause must be prepared to support his stand not only on scientific grounds but also with respect to the dominant values and priorities of the society that he is encouraging to adopt this goal. Thus, the advocate must have a very clear understanding of what he means by outer limits and how choices about outer limits will be made in the various societal and political processes that decide upon basic needs, means of obtaining them and trade-offs in implementing strategies.

It is not reasonable to assume that in every case one can both 'meet basic human needs' (however defined) and 'not transgress outer limits' (however defined). Conflicts will inevitably occur because these are two

distinct objectives. Which one gets priority in such a clash? What criteria are used to make the trade-offs? Who decides? All of these questions are commonly encountered in political situations. That is the point. The objective of 'not transgressing outer limits' is as much a political question as a scientific one. Furthermore, the dimensions of the political questions are more broad than might first have been supposed because, as noted in the first section, man has some 'control' over outer limits both by influencing where the limit is by his actions and by determining if he will exceed the limit if he knows where it is likely to occur. To this can be added the new dimension of 'control' discussed in the second section—the ability to define the contexts in which certain outer limits will be considered (and correspondingly the contexts not to be considered).

These degrees of freedom in the societal, rather than the scientific, determinants of 'not transgressing outer limits' suggest that this objective can be interpreted in a wide variety of ways. Indeed it can almost mean what someone wants it to mean in a given situation by manipulating the way the limit is set, deciding what context of 'outer' is relevant or acceptable, and ultimately deciding whether the 'costs' of exceeding the limit are worth the 'benefits'.

There is at least one way in which some degree of objectivity can be introduced into this process. If the purpose of the objective not to transgress outer limits is not to alter the ability of nature or natural processes to allow one to 'sustain' the meeting of basic human needs in a specific way, then the two objectives might be combined into a single goal such as 'sustainable meeting of basic human needs'. Here the explicit constraint is put on the first objective in a positive way and is really part of the goal which is to meet basic human needs for the indefinite future.

With such a reformulation, the criterion for 'not transgressing outer limits' is very clear. If the transgression would seriously compromise the ability to continue meeting the need then it should not be done. The problem of operationalizing this part of the goal, however, is still not amenable to purely objective analyses and determinations. All that has really happened is that the difficulties have been shifted from the 'outer

limits' analysis to the 'basic human needs' analysis. For example, if sustainable meeting of one basic need (implying making a resource or environmental trade-off) creates a situation where another basic need cannot be met (perhaps because it relies on the thing that was traded off) then a societal determination of priorities among needs must be made; or, since the context of 'sustainability' has to be defined in both space and time, societal determinations of global rather than national sustainability or twenty-four year (to the year 2000) rather than ten-generation sustainability will certainly influence which outer limits are exceeded.

The only way to make the goal of meeting basic human needs without transgressing outer limits into a relatively absolute single-objective statement with respect to outer limits would seem to be to revert back to the very narrow concept of considering exclusively global outer limits. If outer limits were defined solely as the global biophysical conditions on which the human species depends for survival, then the 'types' of limits that should not be exceeded would at least be scientifically identifiable (with enough information) even though where many of them are would still be in part a function of how man chooses to approach meeting his needs.

Yet, even if the problem of defining outer limits were so neatly solved there would surely be people who would want some consideration of limits on resources and environmental systems to be considered other than in a global context and with respect to eradication of the human species. Introducing their concerns into deliberations on basic needs might result in their goal of 'meeting basic human needs taking into account the effects on resources and environmental systems'. What this does is simply introduce another set of parameters in the decision-making process.

This is a rather humble perspective compared to the possibility of getting the 'without' clause adopted in principle and adhered to on a case-by-case basis. However, such a possibility is probably very small in a political sense, at least for adoption in every single country in the world. Therefore, a more modest and realistic stance on the environmental considerations might at least result in the development of method-

ologies and perspectives that one would assume would be given careful attention in the various societal and decision-making processes that make the hard choices among many values. This would in effect be 'internalizing' the environmental considerations into the societal decision-making processes rather than letting decisions be made on the basis of other values and then seeing if environmental values are violated. In this latter case, the original decision will probably not be reversed automatically; at best, it may be reconsidered using a broader set of values and information (which some might argue should have been considered the first time).

See pages 30–1 for Figure 1

Figure 1 outlines the relationships among the various societal and political processes and scientific and technical evaluations that would exist in a process to develop strategies for meeting basic human needs without transgressing outer limits (where outer limits is the broad concept developed in this paper). It is a complex diagram but it attempts to show in conceptual form an even more complex process. Various steps are isolated in the figure (that might be combined in practice) in order to show the different types of values that are introduced for different decisions. This progressive introduction of values (and the persons who have them) into the process makes 'final' decisions very difficult. Thus the process is shown as a 'feedback' process where certain types of information and value judgements are developed later and fed back to modify former decisions. At some point the recirculation is arbitrarily stopped and some persons have obtained what they wanted and others generally have not. The overall situation is made even more complex by the fact that almost every fact identified will change over time.

With respect to the point made above about 'internalizing' environmental considerations in the original determination of needs and how they are met, refer to the box towards the bottom left of the figure denoting the determinations of trade-offs between concerns to meet the need and the desire not to transgress outer limits. This has been isolated to demonstrate the discrete step of introducing environmentally related values at this stage rather than in the box to the left above it. It suggests the type of feedback necessary when the 'without transgressing outer limits' is added after the initial determination of how to meet basic human needs.

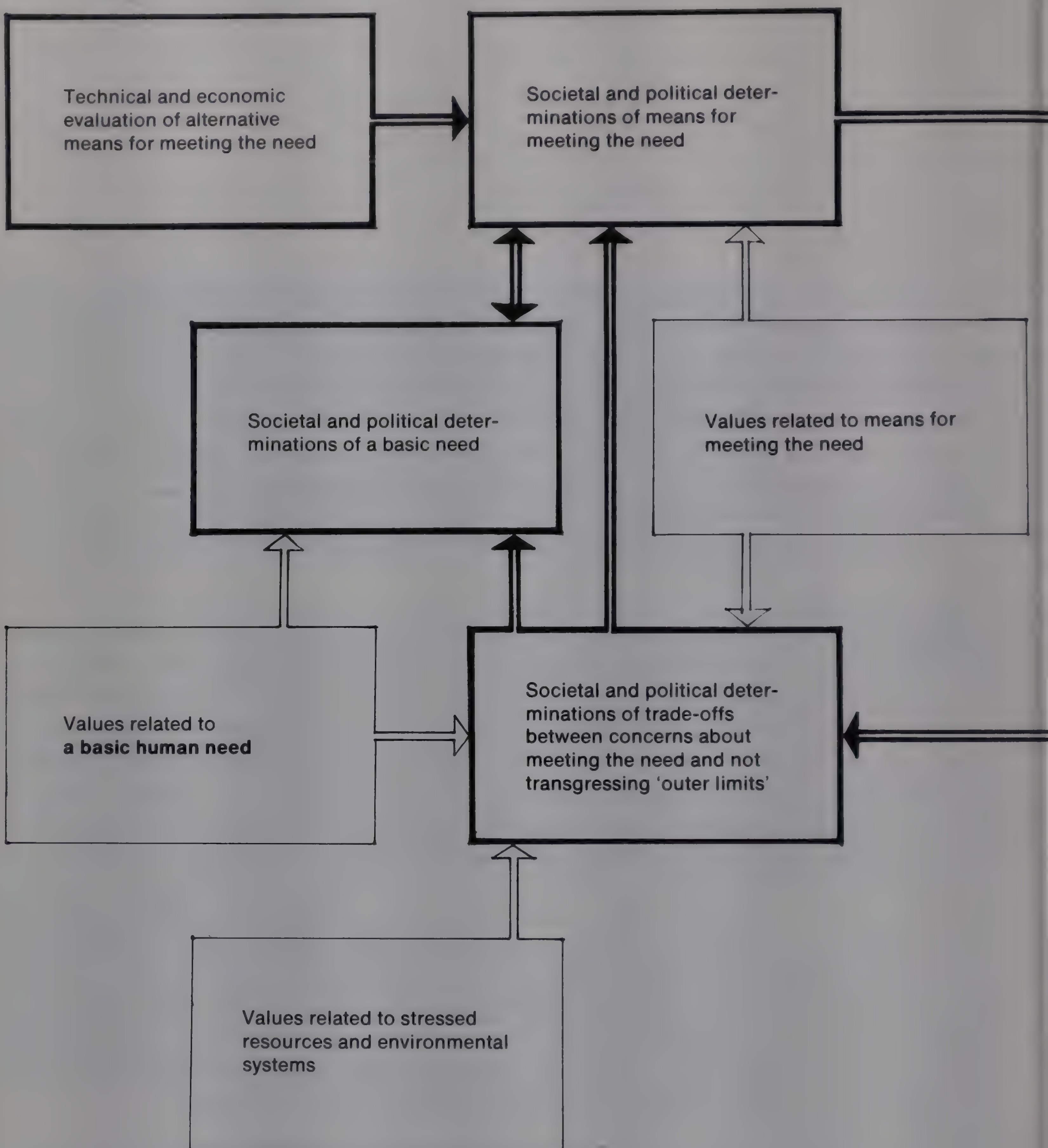
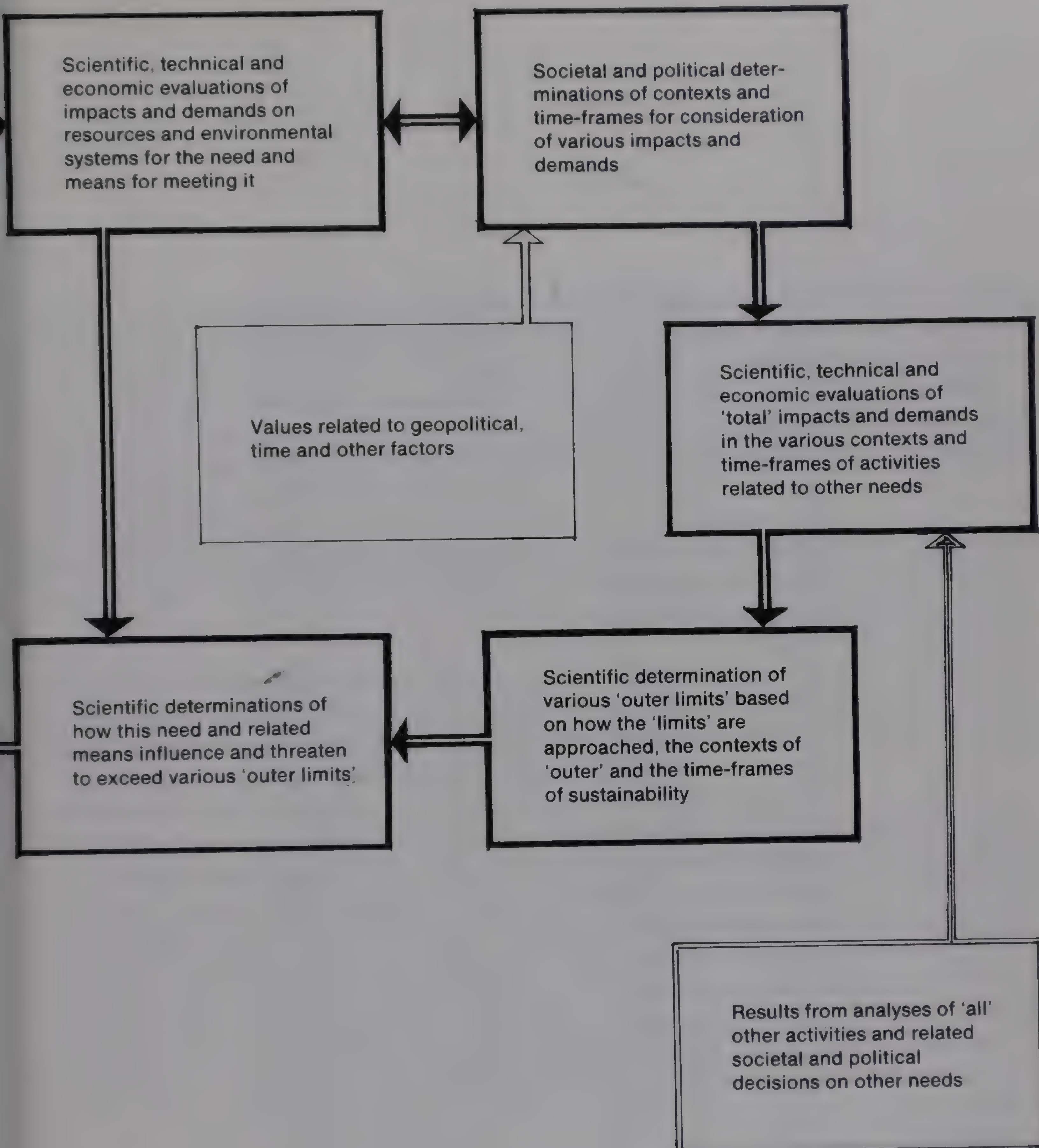


Figure 1 Relationships among societal and political processes and scientific, technical and economic evaluations in developing strategies for meeting basic human needs without transgressing outer limits.



Although this chart outlines the process for only one need, it should be noted that the results of similar processes, for all other needs, enter into it (see the bottom right-hand box above). In addition, it should be noted that, since virtually every factor and process identified will change over time, the various determinations and evaluations must undergo constant revision to reflect truly the dynamic nature of these interrelationships.

When a conflict occurs among the various values, then values related to outer limits may be compromised or ways will have to be found to redefine the needs or to determine other ways of meeting the needs by altering either the approach or the process. The choices are societal and political. It is especially important for the scientist to realize this fundamental point, for it is instrumental in determining the scope of his work, the relevance of his work and the context in which his results are viewed. The implications for developing methodologies for defining outer limits are profound because they suggest an interaction between scientist and society at critical steps in the process that is at present not part of most governmental structures.

The figure also indicates some of the factors that influence how well a society can respond to the goal of meeting basic human needs without transgressing outer limits. In many cases, these factors become limits themselves to meeting the goal. The most important are scientific, cultural, institutional and technological. The scientific factor refers to the state of scientific knowledge and ability to understand and predict the consequences of alternative actions. The cultural factor includes the variety of values found in a society and the societally accepted means of resolving conflicts among them. The institutional factor refers to the basic ability of a society to respond in an organized and effective manner to the great challenges of analysis, decision-making and implementation inherent in this goal. Finally, there are significant technological factors that play a large part in determining whether needs can be met within the capital, labour and resource bases of a country or region, or the world.

Approaches to determining outer limits

The general approach to developing a scientific assessment of some major global outer limits, with its various potential and actual limitations, is fairly familiar. Experiences with numerous multidisciplinary scientific studies on global issues such as climate change, ocean pollution and ecological cycles have provided a great deal of insight into the problems of determining what scientists know, what they do not know, where they agree, and where they disagree, and of developing programmes of focused research and monitoring to fill gaps in knowledge and to reconcile, when possible, conflicting theories or interpretations of data. If outer

limits were simply viewed as scientific factors, it would be a relatively straightforward task to discuss the general types of approaches and preparations that seem to be necessary for such assessments. However, in the process of articulating, elaborating and expanding the concept of outer limits, new and very significant dimensions have been added. These have important implications for the way in which methodologies must be developed.

In the preceding sections the integral relationships between aspects of outer limits that can be determined in a scientific sense and those that are determined by societal values, priorities and decision-making processes have been outlined. This suggests that any approach that attempts to quantify in any but the most rudimentary manner what would be involved in the prescription not to transgress outer limits would have to consider a very wide range of social and political issues. This makes the problem of analysis much more difficult.

The paper in this volume by J C Perkowski (see page 85) gives a description and an example of the way in which some of the scientific and technical aspects of determining global and non-global outer limits might be handled in an increasingly complex system of impact analyses and resource 'accountancy'. This is a first step in handling some of the technical problems, but the types of non-technical issues that are necessary even for this limited type of analysis are readily apparent. It should be noted that the author does not illustrate all the points developed in his paper but only a subset of them. Examples could also be developed to illustrate approaches for other aspects of the concept, eg how different activities might influence an outer limit of a particular environmental system in opposite ways or how the analyses of an outer limit might differ depending on the contexts or frames of reference used for 'outer'.

The approach illustrated in J C Perkowski's paper is based on the following technical considerations:

1 There is a need to have a set of 'building blocks' for the analysis so that the use of resources or the degradation of environmental systems can be quantified in roughly the same manner for meeting different

needs in different places (for example, what the resource 'costs' and what the environmental 'costs' are of producing a barrel of refined oil or a megawatt of electricity using coal or a ton of steel or an automobile).

2 The regressive nature of the analysis of the 'building blocks' must somehow be dealt with to make the analysis tractable (for example, if a barrel of oil is a basic unit of measure for determining the 'costs' of energy-consuming activities, then how does one assess the 'costs' of the oil: it takes energy (oil) to build the steel rig to get the oil, energy (oil) to build and power the ship to transport the oil, energy (oil) to build the refinery to process the oil, and so on).

3 There are numerous alternative strategies for meeting the same need. It is impractical to do a complete technical analysis on all the resource and environmental 'costs' of meeting a need in all of the theoretically possible ways. Some decisions must be made to reduce the number and types of options explored.

4 In the process of meeting all of the various needs of a society or the world, the resource and environmental 'costs' are additive. It is meaningless to say that a specific outer limit will not be exceeded if a certain need is met in a certain way in a certain country. The outer limit is under stress from all the impacts upon it from other needs and other activities within the country and in other countries. A regional or global aggregation of *all* the impacts and demands on any resource or environmental system requires far more sophisticated inventories of present and future activities than are at present conceived. This problem is further compounded when one considers that the outer limit itself is a function of how it is approached. There is a real problem of determining the composite impact when it is approached one way to meet one need and another way to meet another need at the same time.

5 The types of scientific and technical information needed to make these technical assessments are varied and numerous. Inventories of resources, models of environmental system responses and detailed lists of degrees and rates of present and proposed activities are a few of the more apparent information needs. There are at present no plans for developing the types of information systems, scientific models and comprehensive development plans that would furnish enough

specific information for a detailed determination of outer limits except in a very few areas.

The above five points list only some of the more important *technical* considerations in performing adequate assessments of outer limits on a global and non-global basis. The complexity of the analyses is changed qualitatively—not just quantitatively—when social and political factors are introduced. Yet these must be introduced if man's roles in determining the limits are to be considered, if the various contexts of 'outer' are to be reflected in the analyses, and if all of the types of values and decisions discussed in the previous section are to be taken into account in the effort not to transgress certain outer limits.

Such an expansion of the approaches and methodologies will require a great deal more thought and must await further developments of the concepts of 'meeting basic human needs' and the approaches for determining which needs will have priority and the various ways they might be met, technically, socially and politically. Just as the phrase 'meeting basic human needs without transgressing outer limits' is an integrated statement, the approaches to this whole area must also be integrated. This paper and the illustration in Mr Perkowski's paper in this volume constitute one step in an iterative process that must now await similar steps in other areas before further progress can be made.

Conclusions

The principal conclusion of this paper is that the concept of outer limits is much more complex and significant than is suggested when it is applied solely to the global biophysical conditions essential to the survival and well-being of the human species. Especially when it is viewed in the context of meeting basic human needs within less-than-global frames of reference (such as geopolitical regions), the concept must be expanded. The complexities of the concept are even more apparent as one tries to develop an operational definition for specific outer limits and to devise approaches and methodologies for determining and predicting them.

Some of the other important conclusions discussed in this paper are the following:

There are two basic determinants of outer limits: (a) the quantity of existing resources and the laws of nature; and (b) the way man conducts his activities with respect to this natural situation. Both of these must be known before outer limits can be defined for most renewable resources and environmental systems. For non-renewable resources only the first determinant is operative.

Even with complete scientific understanding of biophysical conditions, more information would be required about societal values, priorities and decision-making processes if most outer limits are to be defined.

The word 'outer' in the phrase 'outer limits' refers to the context or frame of reference within which the limits are considered; for example, 'global' outer limits, 'national' outer limits and 'regional' outer limits.

The choice of contexts for various outer limits has major implications with respect to the way they will be defined both scientifically and through societal and political processes.

The choice of contexts is an important factor when dealing with issues of independence, dependence and interdependence.

The goal of meeting basic human needs without transgressing outer limits seems to imply a set of priority decisions which have probably not been made explicitly by many societies.

There are so many societal decisions that influence the definition of outer limits that the objective of not transgressing outer limits can mean very different things even if the scientific content is the same.

The objective of not transgressing outer limits can be interpreted as attaching a condition of 'sustainability' on meeting needs but the definition for this is also subject to many societal decisions.

In reality the objective of not transgressing outer limits probably must be considered as one more (albeit a very important one) set of values to be considered in societal decision-making. This will require a careful development of criteria for considering resource and environmental issues.

Integrating the concept of outer limits into societal decision-making will require careful examination of the nature and limitations of societal and political processes to utilize scientific information, to deal with cultural differences, to institutionalize needed procedures and to utilize relevant technologies.

The acquisition of existing scientific data and a survey of scientific opinion on various outer limits is a straightforward, though not necessarily easy, task. In many cases, however, this will not be sufficient for even preliminary estimates of outer limits both because of the paucity of data and because of the importance of non-scientific factors.

There are several major methodological problems which must be overcome before the primarily technical approaches can be fully developed. These include the determination of 'building blocks' of analysis, the regressive nature of the 'building blocks', the great variety of alternative strategies for meeting a particular need, the additive impacts and demands of all activities, and the development of adequate information bases and models for detailed analyses.

It is hoped that this paper has identified some of the major issues involved in exploring, defining and predicting outer limits, particularly in the context of meeting basic human needs.

Environment and Styles of Development*

by Ignacy Sachs

Introduction

After the anti-novel and counter-culture, zero growth. These are three symptoms, each quite different, of the re-examination of values by a society in search of new ideological responses to problems which have remained insoluble despite the spectacular progress of material growth, or which have arisen as a result of that progress: the generalized malaise of the young, the persistence of poverty, the aggression against the environment, the frustration of the Third World which today is wondering whether the very concept of development, founded upon efficiency, should not be replaced by that of liberation,[1] centred on social justice and the creation of a new man.

Only a profound sense of uneasiness can explain why the theme of zero growth should have so captured the public imagination and why it should have been taken up by public opinion within so short a time, despite the fact that it represents a complete reversal of the ideological outlook of the last two centuries and, still more, of the past fifty years. The frenzy of the mass media, the abuse of the computer to give credibility to this or that idea by investing it with scientific trappings, explain part of this phenomenon but not all. In a world traumatized by the crisis of the 1930s, the appearance of the socialist camp and the emergence of the Third World, growth was in good standing with capitalists and revolutionaries, profit-makers and lovers of justice alike, and the only differences of opinion related to the methods and uses of growth. Today, however, the merits of growth are being questioned and—curiously enough—both the Left and the Right are dividing up into opponents and champions of growth.

The new awareness of environmental problems appears to be both one of the causes and one of the symptoms of this new outlook. True, the degradation of the environment is reaching unpleasant if not dangerous proportions here and there. But would this in itself have been sufficient cause for challenging the very objectives of society? Whatever the causes may be, the debate is now open.

Its oversimplifications, not to say mystifications, tend to be tiresome. Man is presented, now as the arrogant lord of creation and demiurge, now as the prisoner of a machine on a world scale in which production

* This paper, delivered at the Expert Group Meeting on Alternative Patterns of Development, Geneva, 13–18 May 1974, was written for the United Nations Environmental Programme.

and pollution are conspiring to crush him and in which the only kind of history is natural history, in the sense that the depletion of energy introduces an element of irreversibility. For some, the quality of life is obtained at the price of limiting material production; for others it is, on the contrary, proportional to the abundance of products.

Beyond these clumsy efforts we should not fail to observe an emerging political practice which has several claims upon our interest: the long-term future is becoming operational, the notion of organizing possible futures and choosing a desired future is gaining acceptance, an approach to planning which is both global and normative at the same time is beginning to take the place of extrapolation, and the systems approach is replacing the sectoral method legitimized by Cartesianism. The hope of achieving continuous economic and social development hand in hand with rational management of the environment presupposes a redefinition of all objectives and all methods of action. The environment is a dimension of development, and must therefore be internalized at every decision-making level. Problems of resources, energy, environment, population and development cannot, in fact, be correctly understood unless they are examined in relation to one another; and this implies planning within a unified conceptual framework.

For the poor countries the alternative presents itself more than ever in terms of original projects of civilization or of non-development, since to follow the path travelled by the industrialized countries appears neither possible nor, indeed, desirable. The rich countries will in future have to limit their wasteful use of resources, which are in process of relative exhaustion; price fluctuations will enforce this to some extent, but it would be dangerous to leave such matters to the hazards of the market. The elimination of waste and the confinement, within acceptable limits, of the pollution caused by the production or consumption of certain goods will also raise the problem of limiting the growth of material consumption while extending the range of social services (understood in the broadest sense) in order to arrive at a form of development which makes less intensive use of resources and is, at the same time, less harmful to the environment. Such restriction of consumption cannot be achieved without institutional changes more radical than is at present

realized, starting with the redistribution of incomes and the reduction of social inequalities. In addition, there are a number of international problems: assumption of responsibility for the global environment, development of collective international resources regarded as the common heritage of mankind (eg the sea-bed), the impact of an international order capable of helping both to redefine their life styles.[2]

There is enough here to occupy a whole generation of social scientists. In fact, a new connexion will have to be established between the human and the natural sciences in order to achieve a better understanding of the interaction between natural and social processes of which man is both the subject and the object: a subject, let us add, conscious of belonging to nature and of his own gradual growth. Beyond an excessively possibilistic human geography and an excessively deterministic ecology, there is a new synthesis to be made in which the contradictions between anthropology and history will be abolished,[3] and models of energy circulation will be linked with models of the production and circulation of matter and commercial goods. In the meanwhile, the charting of the future must be based on the practice of operational history in the Braudelian sense.[4] In order to learn to define possible futures we must start by dismantling the manifold models of the past, in which population, resources, energy, technology, environment and social institutions are fitted together in a variety of fashions. In this context, *La Terre et l'Evolution Humaine* by Lucien Febvre[5] remains astoundingly topical after the passage of fifty years.

Planning within the new environmental awareness

How is the new awareness of environment problems affecting the planner's field of vision?[6]

Let us begin with a few necessary distinctions and definitions.

The term 'environment' covers, on the one hand, the sum total of identified and identifiable natural resources existing in finite quantities on earth, and, on the other hand, the quality of the environment or, if one prefers, of the *milieu*, which constitutes an important element of the quality of life and which also determines the available amounts and

quality of renewable resources. In fact, the dividing line between the renewable and non-renewable resources is not drawn once and for all. Renewable resources may in the end be destroyed by pollution, and recycling makes possible the repeated use of non-renewable resources. Generally speaking, however, the distinction between these two groups of resources remains valid and useful.

Let us now consider the environment proper. A more ambiguous concept has rarely been known. Of the multitude of proposed definitions, we shall set aside two which are largely complementary.

Definition 1. For the systems approach experts, the environment is made up of everything that does not form part of the purposive system under consideration, though it does affect the performance of that system.[7] As the system endows itself with environment policies, so the environment is less in evidence, and the success of these policies will consequently be measured by the disappearance of the very concept of environment, which will in the end be internalized by the system.

Let us now abandon the game of paradoxes, and draw attention to one operational advantage of the above definition. It invites us to identify better the ecological and societal impacts of the actions undertaken in order to achieve the explicit objectives of the purposive system constituted by development policies. Such an analysis should lead to a redefinition of development objectives with a view to more effective control of the ecological and social impacts of proposed action.

Definition 2. At a different level, UNEP speaks of the total habitat of man. This ecological definition of the human environment has the disadvantage of being too comprehensive. But it can be interpreted more restrictively.

Let us distinguish three subsystems within the environment:

1 The natural environment.
2 The man-made technostructures.
3 The social environment.[8]

Let us then endeavour to study the effects of each of these on the living and working conditions of the different social agents[9] and on the operation of enterprises (this corresponds, in an expanded form, to the problem of positive and negative externalities). The quality of the environment will be described by means of 'objective' indicators and will, at the same time, be apprehended at the level of its perception by the different social agents. Hence the need for a set of indicators ranging from physical and chemical measurements of the quality of water or air to psycho-sociological surveys and including analyses of the availability and accessibility of collective facilities, housing and social services, which will entail simultaneous recourse to statistics and to the time budgets of the various agents.

As already stated, the above two definitions of the environment are not mutually exclusive. The former stimulates the planner's awareness of the interrelations between natural and social processes. The latter concentrates on a more limited problem which is nevertheless of fundamental importance in the choice of development objectives—that of the quality of the environment properly speaking.

Let us now try to establish a relationship between the environment (E) and the population (Pn), techniques (T), natural resources (R) and the product (Pt) (see Figure 2 on page 46).

The development economist's traditional field of vision is represented in Figure 2(a). By means of the available techniques, the population transforms the resources into the appropriate product for purposes of consumption and social reproduction. The dialectic between demographic pressure and resources forms the subject of a large literature dealing with technological and social change. Is it a source of progress or of involution? Put in such general terms, the question cannot be answered. There is no single model to describe the numerous configurations of these variables. On the contrary, systematic efforts on the part of historians and anthropologists are called for to arrive at a typology of situations based on concrete data.

Let us now introduce the environment (E). Figure 2(b) indicates the relevant new relationships:

$R \rightarrow E$, $T \rightarrow E$	Effects on the environment of methods of utilization of the resources and of the production techniques employed.
$Pt \rightarrow E$	Impact on the environment of the methods of consumption of products.
$Pn \rightarrow E$	Impact of human settlements on the environment.
$E \rightarrow R$	Degradation of natural resources due to pollution.
$E \rightarrow Pt$	Conditioning of production through the quality of the environment.
$E \rightarrow Pn$	Environment as a component of the quality of life.

Figure 2 (b) does not, of course, set out to do anything more than point out the relevant relationships which, over and above the traditional factors used in planning, must be taken into consideration within the framework of a strategy aimed at making development compatible with the management of the environment. At best, the diagrams presented

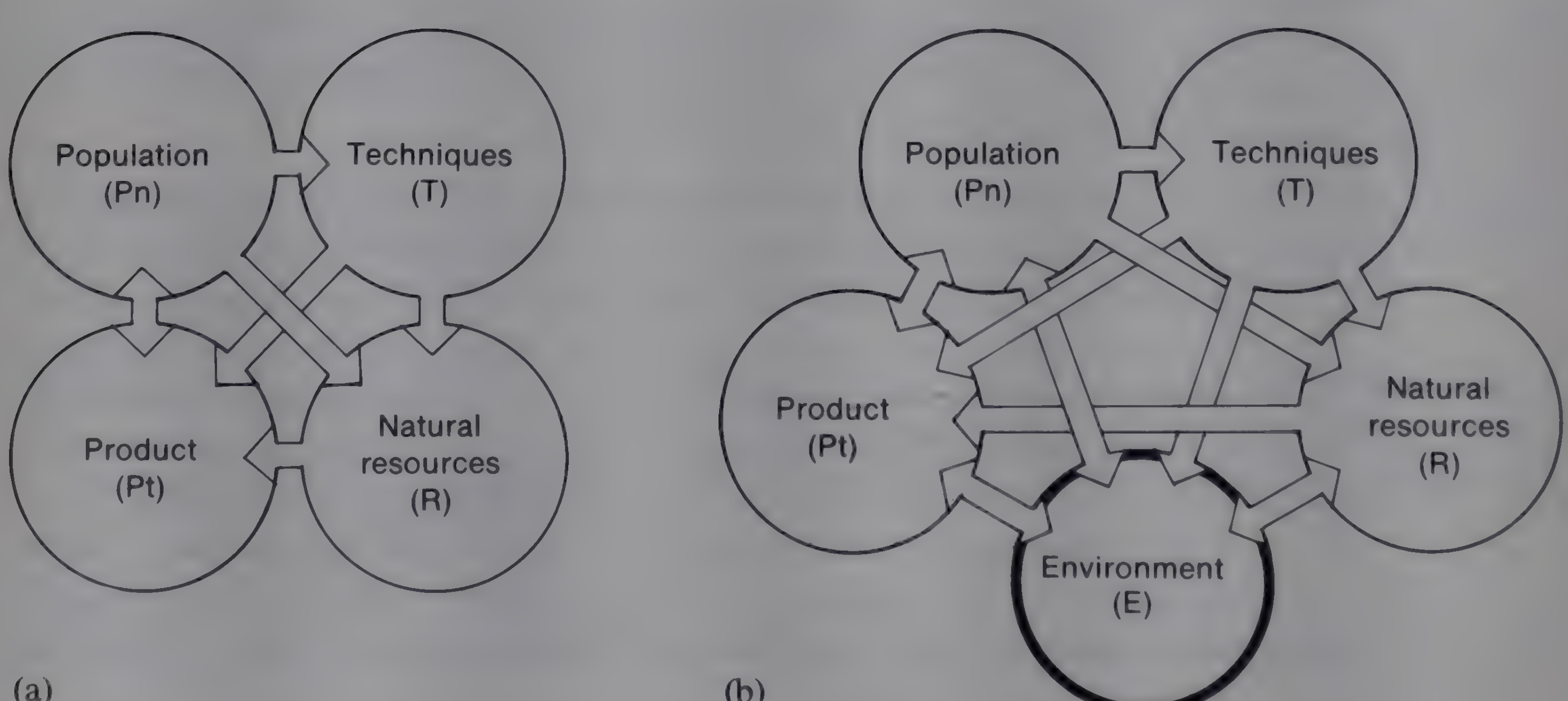


Figure 2 The development economist's traditional field of vision (a) and the introduction of the environment (b)

above have a heuristic value and will have to be modified in every concrete case. Likewise, it would be impossible to indicate once and for all the operational variables for such a strategy. On the other hand, it is possible to identify the critical levels at which action will take place. We distinguish six such levels, a brief description of which is given below:

1 *The consumption structure,* which, in turn, depends on the distribution of incomes and on the totality of values recognized by the society in question.
2 *The socio-political régime* and, more particularly, its manner of dealing with social charges; in market economies, the rule is to let enterprises internalize profits and externalize costs, while in socialist or mixed economies, the state may, in theory, change this rule of the game.
3 *The techniques employed,* where a distinction has to be drawn between, on the one hand, the adding of anti-pollution measures to the escalation of production and of the resulting nuisances and, on the other hand, the introduction of techniques which are not destructive of the environment, ie where the environment factor has been internalized.[10]
4 *The methods of utilization of natural resources and energy,* analysed from the viewpoint of wastage of rare resources, possible recycling of waste products, and even of controlling the obsolescence rates of certain durable goods and equipment with a view to reducing the utilization of rare resources incorporated in them.[11]
5 *Land occupation systems,* since the same types of production and activities lead to very different effects depending on their localization.
6 Lastly, *the size, rate of growth and distribution of the population,* it being understood that population size alone cannot serve as an indicator of its pressure on natural resources; by reason of their high per capita consumption, the few hundred million inhabitants of the rich countries exercise much more pressure than the thousands of millions of inhabitants of the Third World.

In a view of the complexity of the subject and of the many ways in which the relevant operational variables can be fitted together, there can, of

course, be no question of proposing a single development strategy. Thus we come back once more to the search for alternative futures.

Guidelines for ecodevelopment

The foregoing general considerations have led to the formulation of the concept of ecodevelopment.[12] This concept aims at defining a style of development particularly suited to the rural regions of the Third World, though this does not mean that it cannot be extended to include towns, as we shall see in the case of New Bombay.

Its main features or guidelines are as follows:

1 In each ecoregion, efforts are made to develop those of its resources which are specifically needed for the satisfaction of the basic needs of the population in regard to food, housing, health and education, these needs being defined realistically and independently so as to avoid the undesirable effects of copying the consumption style of the rich countries.[13]

2 As man himself is the most valuable resource, ecodevelopment must above all contribute to his fulfilment. Employment, security, the quality of human relations, respect for the diversity of cultures—or, if one prefers, the development of a satisfactory social ecosystem—are all part of this concept. A certain symmetry is discernible between the potential contribution of ecology and social anthropology to planning.

3 The identification, exploitation and management of natural resources[14] is conducted from the standpoint of a forward-looking solidarity with future generations. Depredation is strictly prohibited and the exhaustion of certain non-renewable resources—which is inevitable in the long term—is mitigated by the dual approach of avoiding wastage and making the greatest possible use of renewable resources which, if they are correctly used, should never be exhausted.

4 The negative impact of human activities on the human environment is reduced by resorting to procedures and forms of organizing production which make it possible to take advantage of complementarities of all kinds and to use waste for productive purposes.

5 In tropical and subtropical regions in particular, but everywhere else as well, ecodevelopment relies on the natural capacity of the region for photosynthesis in all its forms. Since guideline number 1, as applied to energy, tends to attach great importance to the use of local energy sources and to give preference to means of transport other than the private automobile, one result should be a reduction in the consumption of energy from commercial sources (and in particular hydrocarbons).

6 Ecodevelopment implies a particular technical style, since the above guidelines cannot in most cases be applied without the development of appropriate techniques.

There are two comments to be made here.

The development of ecotechniques will play a very important role in ecodevelopment strategies for the obvious reason that it is at this level that compatibility can be achieved between various objectives—economic, social and ecological—since technical change would appear to be the principal multidimensional variable in planning.

It would be wrong, however, to assimilate ecodevelopment merely to a technological style. It calls for certain social-organization procedures and a new education system.

7 The institutional framework for ecodevelopment cannot be defined in the abstract without regard to the specific features of each case, any more than can forms of rural institutions proposed by the World Bank for achieving some success at last in the attack on absolute poverty in rural areas and for exploiting the potential of the impoverished masses of the Third World by providing the small peasant with production equipment and techniques suited to his economic and ecological conditions.[15] We can however state three basic principles.

Ecodevelopment calls for the establishment of a horizontal authority which is: (a) capable of looking beyond the interests of particular sectors; (b) concerned by all the facets of development; and (c) able constantly to control the complementarity of the different activities undertaken.

Such an authority cannot be efficient without the effective participation of the populations concerned in the realization of ecodevelopment strategies. This participation is essential for the definition and harmonization of actual needs, for the identification of the productive potential

of the ecosystem and for the organization of the collective effort to develop it.

Lastly, it is essential to ensure that the results of ecodevelopment are not impaired by any plundering of the populations concerned, by intermediaries acting as contacts between the local communities and the national or international market.

These principles can be applied without too much difficulty in areas of the Third World where agrarian reform has been undertaken, and also in every case where living community structures have survived.

8 One necessary complement for the machinery of participatory planning and management is preparatory education. This argument applies *a fortiori* in the case of ecodevelopment, where it is essential also to make people aware of the environmental dimension and the ecological aspects of development. Lastly, as we have already said, it is essential to internalize this dimension and thus to change the system of values and predominant attitudes to nature or, conversely, to preserve and strengthen the respect for nature which is still a characteristic of certain cultures.[16] This result may be obtained by either formal or non-formal education. The Chinese experience is very instructive in this connexion. The ecotechniques developed in China do not differ appreciably from those which other peasant societies have known and practised; but what is new is the education which precedes and accompanies their application,[17] and determines their scope.

In brief, ecodevelopment is a style of development which, in each ecoregion, calls for specific solutions to the particular problems of the region in the light of cultural as well as ecological data and long-term as well as immediate needs. Accordingly it operates with criteria of progress which are related to each particular case, and adaptation to the environment, as postulated by the anthropologists, plays an important part. Without denying the importance of exchanges—and we shall revert to this matter later—it tries to react against the predominant fashion of allegedly universalist solutions and panacea-type formulas. Instead of placing too much emphasis on external aid, it relies on the capabilities of human societies to identify their problems and devise their own original solutions to them, though drawing on the experience of others. It rejects

passive transfers and the spirit of imitation, and gives pride of place to self-reliance.[18] It avoids the pitfalls of extreme ecologism, and suggests on the contrary that a creative effort to benefit from the margin of freedom offered by the environment is always possible, however great the climatic and natural constraints may be. This is amply borne out by the differences between cultures and human achievements in comparable natural environments. But success depends on a knowledge of the environment and on the will to create a lasting balance between man and nature. The setbacks and disasters in which certain societies have foundered offer equally eloquent evidence of the high price which has to be paid for inability to organize the relationships between man and nature.

Applying ecodevelopment strategies

With the assistance of some examples taken from the fields of production, food, housing, energy, industrialization of renewable natural resources, conservation of resources and organization of social services, we now propose to illustrate the scope of application of ecodevelopment strategies, with special reference to ecotechniques.

Food

The 'green revolution', at least in its first phase, is based on a universalist and diffusionist philosophy of development which places too much emphasis on the virtues of transfers of technology and the widespread use of certain 'miracle' varieties of wheat and rice. We are unable here to examine the complex and controversial subject of its results, and we shall therefore merely mention that many critical analyses insist that there are limits to its applicability, since it assumes that the problem of irrigation is solved and it also calls for extensive industrial inputs. In addition, it has contributed to an increasing social polarization and an even more inequitable distribution of income in the countryside. Lastly, it involves ecological risk both because of the reduction of genetic variety and because of the extension of single-crop farming, which is more vulnerable to epidemic disease than mixed farming.

Is it necessary to conclude from this that cultural borrowing and 'modern' agriculture should be ruled out? Though certain champions of

so-called biological agriculture may not agree with us, we reject this conclusion. The mere list of the plants originating from America which are now being cultivated by the rest of the world is enough to demonstrate the absurdity of such an approach, quite apart from the fact that the abandonment of chemical fertilizers and insecticides would lead immediately to a decline in production with very serious consequences. Nevertheless, it is possible and desirable to take a stand against the views embodied in the 'green revolution', and to stress the specific potentialities of each ecoregion in regard to food production.

This leads us to draw attention, first of all, to the importance of ethnobiological research in order to take advantage—if only as a point of departure—of local knowledge of the natural environment, that 'practical science' of primitive peoples and peasants the richness and accuracy of which are constantly surprising anthropologists and ethnobotanists.[19]

The striking diversity of types of agriculture and cultural habits in the world may be analysed from the standpoint either of their adaptation to natural ecosystems or of the transformation of these systems. A classic study by Clifford Geertz draws a comparison between the irrigated terraces of Java—veritable aquaria fashioned by man for rice cultivation—and nomadic agriculture practised on patches of burnt soil which constitutes an imitation of the tropical forest.[20] These are two extreme cases in many respects—the degree of artificiality, and supportable population densities (that of the rice fields is as much as 2,000 inhabitants per km^2); they are also two cases of felicitous adaptation to very different sets of ecological conditions. They reflect two very different orientations for agronomic research, the one relating to highly labour-intensive methods of production involving massive populations living in a small area, the other pointing to the development of mixed farming based on the 'Chacras' of the Amazonian Indians and the gardens of the indigenous population of Polynesia. In the view of many experts, the apparent disorder of the latter conceals a profound rationality.[21]

In general, we have insufficient knowledge about agriculture in humid tropical areas; and priority should therefore be given to ecotechniques applicable in this area, on which a reasonable development pattern for

Amazonia will to a large extent depend. This in itself is a highly controversial theme. Should Amazonia be developed or should it, on the contrary, be kept as a 'reserve', as certain people advocate?

In view of the programmes already undertaken and the existence of mineral wealth in this region, this question is rhetorical, particularly since the argument that the Amazonian forest is one of the 'lungs of the world', producing oxygen, is scientifically unsound. The only real problem is how this development will be effected (and what is to happen to the last of the Indians). Will the development be effected by traditional techniques which involve cutting down the forest[22] in an impossible attempt to transform it into artificial pampas and open fields—or, on the contrary, will it be effected by ecotechniques that respect and are adapted to the forest although they draw profit from it? The results will depend on this basic choice and the ability to create in Amazonia a new 'plant life' civilization. (Can it be that the pessimism of Betty Meggers[23] is due perhaps to the fact that she does not believe in the second possibility, while the optimism evident in the last writings of Gourou reflects precisely a genuine act of faith in human creativity in planning?)

Whatever the case, it will of course be necessary, here as everywhere else, to make use of methods that are already known and belong within the range of 'classical' solutions, even though they may not have been adequately used hitherto. By way of example, we may mention the use of cassava or stripped sugar cane as fodder. But the bulk of the effort must be based on new approaches, of which we shall mention only a few.

First of all, there is forest-farming, which the British call three-dimensional forestry, using the forest as a source of industrial materials and also of animal fodder and human foodstuffs.[24] A glance back to the European Middle Ages will show that forests were long used as 'a cattle fodder yard of unequalled quality', in the words of a Burgundy chronicler of the fourteenth century, quite apart from the role which they have long played as a source of energy. For a long time past, Germans have spoken of the *Nährwald*—the forest as a source of fodder—whose value is calculated in terms of the number of pigs it can feed.[25] The same evidence is provided by the study of certain primitive societies. One example is

the astonishing case of the inhabitants of Ukara Island on Lake Victoria in Tanzania, which has a dense population of livestock breeders whose animals are kept in yards and fed on a mixture of leaves from specially planted trees and from aquatic plants.[26] This opens up prospects of research on trees which can produce human foodstuffs, either directly or indirectly through animal fodder. This research is regarded as essential for the future of agriculture in humid tropical areas, since tree cover seems to be the best cover for the soil in these regions.[27] We may note in passing that forest rehabilitation will call for a change in some ideas profoundly rooted in European civilization, which has grown accustomed to regard forest-clearing as synonymous with economic progress.[28] The rational management of the fauna and the taming of certain species may, in certain conditions, constitute a counterpart and a valuable extension of forest-farming.[29]

Next, we may mention aquaculture or the 'blue revolution' (as opposed to the 'green revolution') in all its aspects: the cultivation of aquatic plants and the breeding of fish and animals in fresh water, lagoons and the sea, instead of a continuous fish-kill. There are abundant examples of this, starting with the familiar case of fish breeding in ponds, where a judicious combination of cultivation practices and fertilization produces very high yields with ecotechniques which require practically no capital investment.[30] Mention may also be made of the possibilities of breeding milk-fish in brackish-water lagoons. From certain lagoons fertilized by sewers in Indonesia it is possible to obtain a yield of 5,000 kg/ha/year. In Taiwan, fish breeding with fertilizers produces yields of 2,000 kg/ha/year; and it has been calculated that in South-East Asia 350,000 km^2 of water are suitable for breeding milk-fish. If these waters were used, they could produce 70 million tons of fish at the Taiwan productivity rate, or the equivalent of the world fish catch.[31] One more difficult but also promising field is the taming of certain species of aquatic mammals which feed on plants. The most notable example might be the sea-cow, which unfortunately is almost entirely extinct. In tropical regions where the soil is ill-suited for the creation of meadows, aquatic plants offer great possibilities as fodder for buffaloes and other animals.

Going on a step further, we come to the production of proteins from

leaves of various kinds,[32] including weeds.[33] Under certain conditions, the plants infesting certain lakes could likewise become raw material for the extraction of proteins, and eutrophication could be prevented in this way.[34]

It goes without saying that both biological pest-control methods and genetic research on local species suitable for exploitation fall naturally within the framework of an ecodevelopment strategy.

Most of our examples have been taken from the humid tropical zones. The problem is quite different for the arid and semi-arid zones, though it is possible to imagine ecodevelopment strategies for these areas as well. Recent studies have pointed to the possibility of developing plants which are particularly suitable for photosynthesis in areas where there is a lot of sunshine, high temperatures and lack of water.[35] It is true that the development of deserts may call for ecotechniques with a high capital-intensiveness, but capital is not lacking in the petroleum-producing countries. A Japanese research project which was originally undertaken with a view to desulphuring the petroleum of the Persian Gulf points to the use of asphalt injected beneath the surface of the desert to prepare certain areas for the hydroponic cultivation of plants genetically suited to the brackish waters existing in the region. It is also worth stressing the political importance of studies of this kind, as a possible contribution to solving the Middle East conflict by developing the resources of the desert. The national aspirations of the Palestinians and Israelis could be satisfied more easily if the ecology of the region were changed; the 'Great Petroleum Scare' and the subsequent sharp rises in prices have made it possible to envisage machinery for financing such an enterprise through a small surtax on petroleum, long-term loans advanced by the petroleum-producing countries and the conversion of the military aid provided to the two opposing camps into a desert development fund.

Housing

Every year, the housing shortage on the world scale increases by some 4 to 5 million units in urban areas alone.[36] The situation in the countryside is far from being satisfactory. Yet, paradoxically, this is a field in which

over the centuries human societies have created dwellings of varying types according to the locality and culture, and well adapted to the ecosystem and the climate,[37] but in which misunderstood modernity has led to such ravages that it has become necessary over recent years to re-invent 'eco-dwellings' reflecting a high degree of ingenuity in the choice of materials, the use of solar and wind energy, water recycling, etc.[38] Housing within the framework of ecodevelopment has three closely linked aspects:

1 The use of building materials of local origin, which are abundant and cheap, ranging from bamboo to mud: this is a problem that has been studied in some detail, but much remains to be done in practice, starting with the rejection of an alien system of values according to which an aluminium roof or a steel and cement house imported at great expense is regarded as a symbol of modernity, even in the bush.

2 The adaptation of the dwelling itself to ecological conditions: as we have already noted, this is the field *par excellence* for the cultural creativity of man, in which it is necessary to take a deliberate step backwards to re-examine traditional housing and possibly draw some inspiration from it. A rigid attitude of reverence for tradition is, of course, undesirable; but architects should pay more attention to anthropology and move beyond the false universalism with which their discipline is at present tainted.[39]

3 Lastly, the integration of ecology and anthropology with urban thinking and with the elaboration of structural plans for towns and all other human settlements: this is by far the most difficult task and the one which has so far been least studied. Hence the importance of the pioneering efforts made by the creators of the New Bombay plan. This city of 2 million inhabitants is to be built with a minimal allocation of resources for housing proper, since the housing is to be provided by self-construction on very small plots; but a very careful plan for the occupation of the ground (which has been made possible by prior purchase of land by the authorities) and rapid collective transport by railway will together provide the inhabitants with living and working conditions which will be very reasonable compared with those in other towns in India.[40]

Energy

The debate on the importance of non-classical sources of energy is highly charged and we have no intention here of taking a position on this controversial subject. It is enough merely to observe that the recent increases in petroleum prices have already upset many hard-and-fast ideas. We shall not say anything of the possible solutions to the problem of large-scale energy production but, in the context of ecodevelopment strategies, we must refer to the importance which might be attached to the elimination of the energy wastage which occurs so often in the consumption style of the industrialized societies, and to the possible contribution which might be made—in the case of domestic energy uses and small production units—by solar energy (for example, for pumps, kitchen stoves and water heaters), wind energy (for the local production of electricity), small dams and even the production of methane from organic sources.[41] These various procedures are justifiable in the conditions of isolation which exist in many rural regions; and they also have the advantage that they can be applied on an even more reduced scale, for example on a single farm. The possibilities of using geothermic energy should, of course, also be carefully assessed where they exist.

Industrialization of renewable resources

One way of combating the possible shortage of certain non-renewable resources might be to restore pride of place to the 'plant life civilizations' which are so well described by P Gourou and whose importance is so evident in Far Eastern cultures.[42] We do not advocate a pure and simple return to the past as do the partisans of the so-called intermediary and 'soft' techniques, but would rather propose some detailed research on the possible use of plant life as an industrial raw material, both for building materials and for chemical products. The rise in petroleum prices makes this all the more necessary, and it increases the urgency of devising techniques for the rational management and exploitation of tropical forests and waters. We believe that a special place should be reserved to 'mixed techniques', ie transforming the qualities of a product by highly technical processing, as the terminal stage in an otherwise traditional production procedure that provides much employment. All

forms of processing and impregnating timber and plant fibres, based on the latest advances in modern chemistry and offering new outlets for certain products of tropical forests and agriculture, provide a good illustration of this concept.

Conservation of natural resources

As we have already indicated in regard to the definition of ecodevelopment, the care for natural resources in the name of a forward-looking solidarity with future generations is an integral part of the ecodevelopment strategy. It seems that it is also an excellent field for 'human investment',[43] since many soil and water conservation activities, reafforestation, etc are suitable for the use of highly labour-intensive techniques. Also, as labour capacity is often available, at least outside the season of major agricultural activity, it is possible to envisage natural resources conservation programmes which would not to any large extent diminish the capacity of a country to undertake other development enterprises. This is one opportunity which should not be missed, as the example of China eloquently demonstrates.[44]

Social services

If, as has been suggested, the social environment is to be considered part of the global environment concept, when taken as meaning the total habitat of man, then an ecodevelopment strategy must naturally include forms and techniques for providing social, educational and cultural services that are adapted to the specific conditions existing in the rural areas of the Third World and that also call for as little capital as possible. Many recent studies and the experience of certain countries prove that such techniques already exist at the level of para-medicine and rural education. In these conditions, Third World countries should be encouraged to attach much more importance to these activities than they are given in the thinking of planners in the industrialized countries, since the possibilities for developing these services are best at a time when social workers' salaries—like all others—are still low. In other words, the poor countries have a comparative advantage in creating many social services, which also offer employment possibilities that are more valuable to

society than the traditional tertiary sector (domestic services and small business). Paradoxically, it is the countries of the Third World which have the best chance of creating genuine welfare states.[45]

Conclusion

The concept of ecodevelopment is intended to be operational. It constitutes a guideline for action (or, if one prefers, a philosophy of development) whose value can be judged only in the light of practice. Is it merely a return to the illusions of community development? Not necessarily so since, by comparison with the community development schemes for the rural areas of the Third World, it is richer in two respects: first, it is a critical reflection on the failure of those schemes and thus an attempt to do better, particularly at the institutional level, and second, it represents an opening on to natural and social ecology which is revolutionizing the habits of thought of development workers.

The application of the concept does, however, require a sustained research effort accompanied by pilot activities subject to critical review, so that permanent feedback is established between practice and action-oriented research.

In particular, we must promote the collation and circulation of information on ecodevelopment experiments, as identified and described by anthropologists, historians and human geographers, and also on ecotechniques developed and applied by different indigenous popular cultures and, to an increasing extent, by certain research laboratories. The purpose of this will be threefold: to inspire the imagination of research workers and persons responsible for regional planning; to assist in the training of ecodevelopers; and, occasionally, to suggest experiments in adaptation, particularly between similar ecozones. This will require a vast programme of comparative and interdisciplinary research and journeys in space and time, undertaken through a network of scientific collaboration in which our colleagues of the Third World will have primary responsibility, since encouragement must be given above all to exchanges within the Third World, on a South–South axis, by insisting on cooperation between ecoregions which are similar but situated in areas geographically distant from one another.

On the basis of these exchanges, supported by specific case studies, it would be possible to define points of interest to serve as focuses for the collaboration of biologists, technologists and planners: three professions which in the past have had too little contact with one another. Their exchanges would lead to the formulation of research priorities on eco-techniques and organizational forms of ecodevelopment.

Without waiting for the results of all these exchanges, it is possible even now to undertake certain pilot activities, designed to show that regional or micro-regional development strategies would be improved if they were oriented in the direction of ecodevelopment. The elaboration of ecodevelopment scenarios would make it possible, in a first stage, to take stock of actual knowledge—or gaps in knowledge—on this matter, to test the participatory and unified approach to planning and to train ecodevelopers. In a second stage, it is conceivable that the ecodevelopment concept will simply be assimilated by the regional planners and will thus be generally used to contribute to the identification of development styles appropriate to each specific case; in the long term, the internalized environment as a permanent dimension in the field of vision of the planner is destined to vanish as a specific field of action.

Notes

1 D Goulet, *The Cruel Choice—A New Concept in the Theory of Development,* New York, 1973, pp. xii–xxi.
2 See in this connexion the report of the United Nations Symposium on Population, Resources and the Environment (Stockholm, September to October 1973).
3 This social metascience is postulated and practised by M Godelier. See *Horizon,* 'Trajets Marxistes en Anthropologie', Paris, 1973, pp. 13–82.
4 See in this connexion our article 'Histoire Globale et Prospective du Tiers Monde', *Diogène,* No. 73.
5 L Febvre, *La Terre et l'Evolution Humaine,* Paris, 1922.
6 The present piece of work partly represents our study 'Ecodesarrollo: Un Aporte a la Definición de Estilos de Desarrollo para América Latina' prepared for the Economic Commission for Latin America (ECLA) in July 1973.
7 W Churchman, *The Systems Approach,* New York, 1968.
8 The human environment is of course made up of men (see T Maldonado, *Environnement et Idéologie,* Paris, 1972, p. 15).
9 In this respect F Engels' work on the conditions of the working class in England stands out as a classic of the literature on the environment.

10 The category of non-destructive environmental technologies is broader than that of 'soft technologies', defined as inflicting no damage to the environment, as not calling for a great deal of capital or for high qualifications and able moreover to be applied on a small scale. See in this connexion: P Harper, ' "Soft Technologies" and the Critique of the Western Model of Development', in *Perspectives,* Vol. III, No. 2, 1973, and our article published in the same review under the title ' "Techniques Douces", Projets de Civilisation, Développement'.

11 One cannot over-emphasize, in this context, the importance of setting up a patrimonial accounting system for nature in order to be in a position to detect the consumption entailed by the irreversible whittling down of the capital of nature or, if one prefers, the rate of exploitation of the environment (for this last concept see R G Wilkinson's fine book, *Poverty and Progress. An Ecological Model of Economic Development,* London, 1973, and also M F Dasmann, *Ecological Principles for Economic Development,* London, 1973).

12 Maurice F Strong, former Executive Director of the United Nations Environment Programme, launched the idea of ecodevelopment at the first meeting of the administrative board of the programme, held in Geneva in June 1973.

13 As the Pakistani economist and World Bank Policy Planning and Program Review Director Mahbub ul Haq has rightly written, 'the developing countries have no choice but to turn inwards, in much the same way as Communist China did twenty-three years ago, and to adopt a different style of life, seeking a consumption pattern more consistent with their own poverty—pots and pans and bicycles and simple consumption habits—without being seduced by the life style of the rich' ('Crisis in Development Strategies', *World Development,* Vol. I, No. 7, 1973, p. 29).

14 It should never be forgotten that the very concept of natural resources depends on culture; as C O Sauer has said, natural resources are a civilization's estimates of its environment (quoted by P Gourou, *Pour une Géographie Humaine,* Paris, 1973, p. 240).

15 See in this connexion the address by Robert S McNamara, President of the World Bank, to the Board of Governors, Nairobi, 24 September 1973, and the work of the United Nations Committee for the Planning of Development and the United Nations Research Institute for Social Development (UNRISD) on the unified approach to planning.

16 Development as it is traditionally defined always signifies ascribing an unconditional priority to culture over nature. However, as is stressed by Claude Lévi-Strauss, among primitive peoples the relation between culture and nature assumes a certain ambiguity: the latter is at one and the same time pre-culture and sub-culture, but, above all, it contains a supernatural component (*Anthropologie Structurale,* Vol. II, Paris, 1973, p. 374).

17 See in particular J B R Whitney, 'Ecology and Environmental Control in China's Development Experience', special issue of the *Annals of the Ameri-*

can Academy of Political and Social Science, March 1973, Vol. 31, No. 1, pp. 95–109.

18 This English term consecrated by Emerson, used again in the context which is of interest to us by Gandhi, and more recently again by Nyerere (*Ujamaa: Essays on Socialism,* Dar es Salaam, 1968) has connotations which the usual French translation, 'développement autocentré', renders very imperfectly.

19 See, among others, C Lévi-Strauss, *La Pensée Sauvage,* Paris, 1962, pp. 3–47, and J Barrau, 'Plantes et Comportements des Hommes Qui les Cultivent. L'Oeuvre Ethnobiologique d'André Haudricourt', *La Pensée,* No. 171, October 1973, pp. 37–46.

20 C Geertz, 'Two Types of Ecosystems', in A P Vayda (ed.), *Environment and Cultural Behaviour,* New York, 1969, pp. 3–25.

21 See for instance for the 'chacras' of Indians, B J Meggers, *Amazonia: Man and Culture in a Counterfeit Paradise,* Chicago, 1971, and S Varese, 'Au Sujet du Colonialisme Ecologique', *Les Temps Modernes,* April 1973; for the gardens of Polynesia, R A Rapaport, 'The Flow of Energy in an Agricultural Society', *Scientific American,* September 1971.

The International Rice Research Institute has begun a research programme on 'multiple cropping' conceived as a carry-on from the 'green revolution', keyed to the humble peasant who lacks capital and access to irrigated lands, but could grasp perfectly well a new technique which would depend essentially on his labour and on knowledge of the environment and would afford him a possibility of increasing and diversifying his production (see G Conway and J Romm, *Ecology and Resource Development in Southeast Asia,* The Ford Foundation Office for Southeast Asia, 1973).

22 Naturalists can be found who justify the cutting down of the forest by pseudo-scientific arguments. Has not Henrique Pimenta Veloso, adviser to the Brazilian Government, explained that the Amazonian forest is in the process of growing dangerously old and of degenerating beneath the weight of the liana and that 30 per cent of it must be cut down before it is too late (*O Estado de São Paulo,* 4 September 1973)? His statements called forth a caustic commentary from the *Jornal do Brasil* suggesting that the erudite ecologist had the soul of a lumberjack and of a cattle-breeder.

23 The book already referred to by Meggers bears the significant subtitle of counterfeit paradise. Gourou, whose assessments of the virtual possibilities of Amazonia have greatly evolved, writes in a recent work: 'It is more realistic—and more scientific—to think that it is on account of the lack of farming techniques and adequate backing technologies that it has not been possible for a permanent and abundantly productive agriculture to be established in Amazonia. If an ingenious civilization had risen up in Amazonia, there would be no lack of people to say that it had been favoured by the vast expanse of arable land, by the abundance and regularity of the rains and by an admirable navigable network, unique in the world' (*Pour une Géographie Humaine,* op. cit., p. 95).

24 See by way of example the excellent article by James Sholto Douglas, 'Agrisylviculture to Increase Nature's Food Production', *Impact of Science on Society* (Unesco), Vol. XXIII, No. 2, 1973.

25 See P Deffontaines, *L'Homme et la Forêt,* Paris, 1969, pp. 37 and 44. See also, for examples of the role played by the forest in providing food during the early Middle Ages and the integration of agriculture, stock-raising and sylviculture, Georges Duby, *Guerriers et Paysans, VII^e–XII^e Siècles,* Paris, 1973.

26 P Gourou, *Leçons de Géographie Tropicale,* Paris, 1971, pp. 160–1.

27 See R Revelle, 'Population and National Resources—Land and Water Resources', document prepared for the United Nations Symposium on Population, Resources and the Environment, Stockholm, 26 September to 5 October 1973.

28 In this connexion European culture is in opposition to that of the Moslem East, as has been rightly noted by J Le Goff: 'A great mantle of forests and heaths interspersed with cultivated clearings of varying degrees of fertility, such is the face of Christendom—like a negative of the Moslem East, a world of oases in the midst of deserts. Here wood is scarce, there it is plentiful, here trees are civilization, there they are barbarism. The religion which rose up in the East in the shelter of palm trees made its appearance in the West at the expense of the trees, the refuge of pagan spirits, which were mercilessly cut down by monks, saints and missionaries. All progress in the medieval West took the form of land clearance, of fighting and vanquishing the brushwood and bushes or, if it was necessary and if technical equipment and courage made it possible, the woods, the "gaste forêt" of Percival, the *selva oscura* of Dante' (*La Civilisation de l'Occident Médiéval,* Paris 1967, p. 169).

29 The great English biologist Julian Huxley reached a similar conclusion with regard to the African savannas. See 'Riches of Wild Africa' in *Essays of a Humanist,* Harmondsworth, 1966, pp. 177–201.

30 H Dickenson describes Chinese practices whereby up to 8,000 kg of fish are obtained yearly for each hectare of pond subject to a very sophisticated management, involving the feeding of fish with snails, the chrysalises of silkworms, and the leaves of sweet potatoes, and enriched by pigs' dung (*Rural China,* 1972, report published by the School of Engineering Science, University of Edinburgh, p. 133). In Peruvian Amazonia we visited an example of experimental pisciculture where the fish were fed on termites, which opens up possibilities of managing the trophic chains in a new way. For an exhaustive overview of the problems of aquaculture, see J E Bardach, J H Ryther and W O McLarney, *Aquaculture. The Farming and Husbandry of Freshwater and Marine Organisms,* New York, 1972.

31 P Gourou, *Pour une Géographie Humaine,* op. cit., p. 27.

32 See the studies carried out by N W Pirie, a pioneer in the field, and in particular the following volume (edited by him): *Leaf Protein: Its Agronomy,*

Preparation, Quality and Use (Blackwell Scientific Publications for the International Biological Programme), Oxford and Edinburgh, 1971.

33 See S B Gore and R N Joshi, 'The Exploitation of Weeds for Leaf Protein Production' in *Tropical Ecology with an Emphasis on Organic Production*, Athens (Georgia), 1972, pp. 137–46.

34 Thus at the eleventh International Great Dam Congress, held at Madrid in June 1973, the Soviet delegation announced the construction in the Ukraine of a factory for the extraction of proteins from the plants which infest the artificial lakes.

35 See O Björkman and J Berry, 'High-Efficiency Photosynthesis', *Scientific American*, Vol. 229, No. 4, October 1973, pp. 80–93.

36 *World Housing Survey*, New York, United Nations, 1973 (doc. E/C.6/129).

37 See in this connexion: A Rapaport, *Pour une Anthropologie de la Maison*, Paris, 1972; P Deffontaines, *L'Homme et Sa Maison. Géographie Humaine*, Paris, 1972; and, with regard to the Arabic house, Hassan Fathy's excellent book, *Construire avec le Peuple*, Paris 1971. Gilberto Freire has studied the adaptation to the ecosystem of the Brazilian colonial house in *A Casa Brasileira*, Rio de Janeiro, 1971.

38 As one example among others, mention may be made of the experimental house built at McGill University in Canada: sulphur, a by-product of oil refining, was used as material, wind energy was harnessed to produce electricity, solar energy was used for cooking and heating water. The creativity of the designers showed itself above all with regard to water husbandry: separation of three qualities of water in terms of use, recycling and purification with the aid of solar energy, collecting of rain-water, condensation of air humidity, choice of simple and judicious methods of sprinkling for washing, etc (A Ortega *et al.*, *The Ecol Operation*, Montreal, 1972).

39 Let us refer once again, by way of example, to Hassan Fathy's fine work.

40 See Charles Correa's excellent study, 'Self-Help City, the Internal Organization of Metropolitan Areas', submitted to the United Nations Symposium on Population, Resources and the Environment, Stockholm, 26 September to 5 October 1973.

41 Either on the basis of algae, or on the basis of dung, as is already being done in India; in the latter case, this constitutes important economic progress, for cow-dung traditionally serves as fuel, wood being scarce; the new process makes it possible to extract fuel, to meet the needs of the village, by means of a simple device, and also to obtain manure.

42 See P Gourou, 'La Civilisation du Végétal', *Indonésie*, No. 1 (5), 1948; and, by the same author, *La Terre et l'Homme en Extrême Orient*, Paris, 1972, in particular pp. 26–9.

43 See in this connexion E Raynaud's work, *Investissements Humains: Illusions et Réalités*, Paris and The Hague, 1969.

44 See in this connexion the article, already mentioned, by J B R Whitney, 'Ecology and Environmental Control . . .' and the study made by Chang

Kuang-tou, Chen Chun-ting, Li Kuei-fen and Liu Ling-yao, *Construction of Dams for Water Conservancy,* Peking, 1973; and for a general formulation of possibilities with regard to the application of labour-intensive methods for the conservation of resources, see our contribution to the Founex Symposium of 1971: 'Environmental Quality Management and Development Planning: Some Suggestions for Action', in *Development and Environment,* The Hague and Paris, 1972.

45 For further details, see our article: 'A Welfare State for Poor Countries', *Economic and Political Weekly,* Vol. VI, Nos. 3–5, January 1971.

The Interaction of Ecological and Social Systems

Local Outer Limits in Development*

by M Taghi Farvar

Two principles of development

Development usually aims at increasing agricultural production, at creating better public health by attacking diseases which are characteristic of underdevelopment and at intensifying industrialization for the creation of more jobs and consumer (as well as capital) goods, power production, etc. These ends can be achieved by altering the environment in a given area, ie by changing the balance of nature. The balance of nature is the subject-matter of ecology. When it is altered in our favour, we have development. When such alteration results in upsetting the balance against our interests, we have environmental deterioration. Therefore, development and environmental degradation are the opposite ends of the same spectrum Unlike the usual belief that development has to cause environmental degradation or that environmental quality has to be achieved at the cost of slowing down development, we can see that one crucial characteristic of development is a beneficial alteration of the ecological system (or the balance of life). Viewed from the environmental point of view, development is to be regarded as synonymous with improvement of environmental quality.

The other important characteristic of development is increased access by the common man to vital resources, ie equitable redistribution of resources. In this light, the problem of agricultural development or of health-care services, for example, becomes in the first place a problem of how better to redistribute what is already available in food, fibres and health-care resources.

In a meaningful context for development these two characteristics have to go hand in hand. Development is therefore (a) an equitable redistribution of available resources, and (b) a beneficial alteration of the ecological balance to increase further the access of all the people to improved material well-being which comes from the new balance.[1]

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Inner and outer limits

The foremost goal of development should be to meet the basic minimum needs of the population, needs such as adequate and nutritious food, access to health care, satisfying employment, reliable shelter, sufficient sources of energy, a healthy environment—in short, all that human beings need in order to live in a state of biophysical and psychosocial

fulfilment. Each of these minimum needs has an implication in terms of the environment, since it involves the commitment of a certain quantity of environmental resources per person to satisfy the need. These minimum environmental resources needed to achieve development are called 'inner limits'.[2]*

Obstacles to approaching the inner limits (meeting the basic needs) are usually of two kinds: (a) a social system characterized by injustice, privilege and maldistribution; and (b) an ecological system whose productive potential is low, or which has been driven beyond its carrying capacity.

If a human ecosystem has surpassed its carrying capacity, or if the ecological relationships have been imbalanced with undesirable effects on its viability and sustained productiveness, we shall say that its development has exceeded its 'outer limits'.[3]

Thus even after achieving the minimum needs, there is a vast margin for effective action between the inner and outer limits of development. We shall return to this concept at the end of the paper.

Violation of local outer limits in the Third World

Something has gone wrong with the balance of nature in practically every part of the Third World. The large body of evidence now available makes this amply clear.

In Peru the valleys on the Pacific coast are suitable for intensive irrigated cultivation, such as cotton. One of these, the Cañete valley, has become a well-known example in the field of pest control for agricultural production. In the early 1950s, insecticides used to control cotton pests gave rise to highly resistant 'super-pests', which could not be controlled by any chemical means available. The biological control mechanisms were destroyed as a result of pesticide use. The balance of nature—through useful parasitic and predatory insects—was undesirably upset. The local outer limits in the Cañete valley had been exceeded. A disastrous crop failure followed in 1956. In this case a number of ecologically oriented entomologists, helped by an alarmed farmer population, were able to

* The concept of 'inner limits' was used in the Cocoyoc Declaration to focus attention on the urgent unmet needs of the majority of the world's population. Here we shall speak interchangeably of 'reaching the inner limits of development' or of 'satisfying minimum needs of the population'.

take immediate steps to outlaw the use of the synthetic organic pesticides that had caused the problem, and they succeeded in re-establishing the balance of nature.[4]

The farmers in Mexico, Central America and parts of the Middle East have been less fortunate. In Egypt a drastic decline in total production of cotton occurred in 1961 with the yield dropping from 608 to 402 kilograms per hectare, caused by insecticide resistance and relaxation of non-chemical control methods due to new faith in insecticides.[5] In 1970, when a similar disaster struck cotton-producing areas of north-eastern Mexico (such as the Tampico region), their production ceased nearly completely.[6] Large areas of Central America have faced a similar failure in the late 1960s and early 1970s. Cotton is not the only crop that has suffered from reliance on insecticides. In Malaysia and elsewhere, cocoa, oil palm, rubber and other crops have undergone heavy attacks by pests unleashed as a result of pesticide use.[7] Such results following pesticide usage are now commonly expected from this approach to pest control. In these examples the outer limit which has been violated is the ability of the insect community to maintain a balanced set of complex ecological relationships which is normally conducive to a surplus production harvested by man.

These incursions on local outer limits are not the only instances of harm done by pesticides used in agricultural development. In Central America, for example, thousands of highland Indians and other workers who migrate to the vast plains of the Pacific coast annually to pick the cotton crop, are poisoned by insecticides and hundreds of documented cases of death are recorded per year. The latter, of course, is the ultimate violation of local outer limits.

An inquiry into the reasons for this repetition of disastrous mistakes shows that it is not unrelated to the private-market oriented modes of production. For example, in Central America, as in many other areas, the pesticide salesmen, who represent foreign manufacturing corporations and who are motivated by profit alone, have a virtual monopoly on technical information available to the public and the farmers. There are no qualifications required for dispensing highly toxic poisons other than the ability to sell a product. In most instances we have been too

quick to allow the import and unchecked sale of modern synthetic chemicals without taking precautions such as the setting up of laboratories to establish standards and monitor effects on the people and their ecosystems, or the instituting of a firm legal system to prevent the exploitation of our peoples by profit-motivated corporations. For example, as a result of intervention by such corporations, every law proposed in the USA for banning or limiting the use of DDT and other pesticides has had a provision specifically exempting foreign exports of the material. One of the disastrous results of this corporate-oriented policy of dominant industrialized western countries such as the USA happened in Iraq in 1972 when 80,000 tons of imported wheat and barley coated with organic mercury fungicide caused mass poisoning of Iraqis. At least 400 died initially and 5,000 more were admitted to hospitals for treatment, with the actual number affected probably much higher. The poison, which often works slowly and enters ecological cycles and food chains, reached people through poultry, meat, river fish and bread. The fungicide had been banned in the USA, Sweden and a number of other industrialized countries, but this did not bar its export to Iraq by profit-seeking US corporations.[8] Here and in the Central American situation, we see clear cases of the way in which the faulty social system of the dominant countries has forced the violation of the local outer limits of the dependent countries.

A further examination of some development problems will make this point clearer. In most developing countries those who own the means of production are forcing a shift from subsistence crops (food, fibre and other needed crops primarily for use by a local population) to cash crops, often for export to industrialized countries. This change from using nature for the satisfaction of human needs to exploiting it for profits is inherent in the so-called 'green revolution' approach to agricultural development which has been imposed on many developing countries by market-oriented industrialized countries and their helpers. The helpers include organizations such as the Ford and Rockefeller Foundations and the Agricultural Development Council in the USA: these are tax-exempt organizations which frequently further the interests of the giant transnational corporations through their sponsorship of projects that involve heavy inputs from these corporations. These front runners that develop

and diffuse 'miracle' seeds, chemicals and machinery in fact act as the charitable edge of a much thicker intrusion into the vulnerable socio-ecological environment of dependent Third World countries. They have set up CIMMYT (the International Centre for Maize and Wheat Improvement) in Mexico and IRRI (the International Rice Research Institute) in the Philippines and several similar operations. The Food and Agriculture Organization (FAO) of the United Nations, and almost all bilateral aid-giving agencies, are also influenced by these organizations and, in effect, sometimes in spite of a humanitarian intent do little more than propagate the interests of the transnational agri-business corporations by driving the wedge deeper into the Third World setting.

In the Indian subcontinent the green revolution, spearheaded by 'miracle' new wheats, caused a tremendous consolidation of land in the hands of large-scale commercial farmers as thousands of peasants were driven out to give way to the new need for machine cultivation and harvesting, uniform irrigation and pest control without which the seeds could not flourish. Far from being the solution to all the problems of the rural areas as they were purported to be by their front-runners,[9] these 'seeds of change' have only succeeded in changing things for the worse. By depriving the masses even of their subsistence livelihood, the green revolution or, more appropriately, the factory-farming approach has violated not only the outer limits of the ecological system, but also the minimum needs of the population. Another example of this phenomenon occurred in 1968 in Iran, where initial reports of impressive yields in other countries led to the introduction of 'miracle' wheats. A new strain of virulent wheat rust to which the native varieties had been resistant began to flourish. The new varieties, which were supposed to be rust-resistant, began to succumb and many farmers lost their entire crop. There were reports of widespread hunger.[10]

In tropical regions like Central America and the Amazon region a change to vast monocultures has been very destructive of the soil. Just a few years of mechanized agriculture in many areas of the Amazon basin have turned the lush forest into infertile deserts covered with a brick-like leached soil called laterite.[11] This approach of making a quick profit out of humid tropical lands continues as vast jungles in Brazil and elsewhere

are opened up to profit-seeking corporations and large-scale, private plantations.[12] Little attention is paid to more compatible means of meeting human needs from tropical regions, such as 'tropical gardening', shifting agriculture, etc.

The Central American example is instructive in other ways. Two decades of quick-cash cotton production have eroded the top-soil accumulated over more than a millennium. Monoculture has also encouraged outbreaks of insect pests which have alarmed the large growers and led to the most widespread and intensive use of pesticides, much to the detriment of the environment and human health.

The position of economic dependence that Third World countries are forced into can be seen from the following example. About 2 kg of cotton bring in $1 of foreign currency in Guatemala, of which $0.75 or three-fourths leave the country immediately to pay for the synthetic insecticides, fertilizers, spray-planes, etc. Calculations show that as little as 1 or 2 per cent of the cotton grown in Guatemala could probably bring in the same amount of net foreign-exchange earnings as raw cotton export, if finished products (say, Guatemalan shirts) were being exported to the countries of destination.[13] If these shirts and other finished products were made locally as a cottage industry using existing indigenous methods, the household economy would improve and no expensive capital outlays of foreign-made machinery would be required. Even if more technologically advanced manufacturing techniques were employed many jobs would be created for the local population. Such an approach to development would also leave most of the area now devoted to cotton (the best and most fertile lands) free for other uses (such as food production), would prevent erosion and poisoning of the top-soil and would result in even greater meaningful economic growth—provided the people were allowed to participate maximally in the development and to benefit fully from their efforts. Here is indeed a case where an exogenous factor—the inherently unjust international economic order—intrudes on the local outer limits of the human ecosystem in a dependent country, and prevents even the minimum needs from being met, by keeping the local population badly fed and housed and in despicable conditions of health.

Another instance of the interaction of social and ecological systems can be illustrated by incompletely executed land-reform programmes. Over a decade ago Iran passed its Land Reform Act, which provided for the division and instalment sale of large land-holdings among some peasants in the country. Partly in an effort to encourage modern agricultural production techniques an exemption was made for those who mechanized their land. One unfortunate result was a tractor rush by many large-scale land-owners who possessed marginal lands. In rapid succession pastures, forest and semi-arid lands, and steep hillsides succumbed to the onslaught of the mechanical plough. The effect was erosion and the destruction of many formerly productive pastures and other marginal lands unsuitable for mechanization. The social decision to limit land reform caused the local outer limits to be exceeded in marginal lands. The repercussions were far-reaching. Many nomadic populations, for example, helplessly witnessed the shrinking of their summer and winter pasturing grounds: the resources with which they had always met their minimum needs and which had even supplied many animal products for the country were fast disappearing.

Public health schemes constitute another striking example of the interaction of social and ecological systems affecting the inner and outer limits.

Health, says the World Health Organization (WHO), is the state of complete physical, mental and social well-being. In other words, it is a state of balance between the individual and his biological and social environment. It is therefore closely akin to the state of development in a community. An underdeveloped society is less healthy; development itself, as we have defined it, is a precondition for health. The most effective action that can be taken to eliminate the conditions of unhealthiness is in fact action leading to eradication of underdevelopment, ie redistribution of resources and environmental improvement.[14]

Rather than attempting to do away with the very conditions of underdevelopment, the predominant approach has been a narrow conception of single-disease eradication. WHO, as a sectoral agency and in spite of its broad, socially oriented definition of health, has been the standard-

bearer of this concept, developing uniform methodologies for the narrow approach. A case in point is the world malaria eradication programme.

No other disease has been able to marshal as much public resources for its eradication as malaria. Soon after WHO was set up, a small group of people, chiefly in the Rockefeller Foundation, were able to persuade the organization to undertake a global paramilitary operation purporting to wipe out malaria through the universal species eradication of *Anopheles* vectors of malaria. They developed a uniform technology of malaria eradication, divided into four phases: preparation, attack, consolidation and maintenance. Even the terminology was taken from military jargon. Encouraged by initial success on a Mediterranean island, the malaria eradication armies waged chemical warfare in country after country, conquering many villages and intruding on practically every household. Unfortunately but predictably, the complexity of the biosocial environment was greater than to allow a victory for this well-intentioned but simple-minded approach. In Central America, nearly two decades and four insecticides later, we have reached the end of the road. In rapid succession dieldrin (sprayed once a year), DDT (twice a year), malathion (three times a year) and propoxur (four times) have induced physiological and/or behavioural resistance in *Anopheles albimanus,* the main vector. In Honduras the incidence of malaria has reached or surpassed pre-eradication levels. In India, southern Iran, Iraq, Pakistan and Sri Lanka insecticide resistance and/or resurgence of malaria have brought the eradication attempts to a standstill. In Ethiopia in the early 1960s recrudescence of malaria caused some 150,000 deaths in an area where malaria was virtually not lethal previously: a temporary interruption of transmission had caused the natural immunity of the population to disappear. In South Viet-Nam parasite resistance to drugs has become a major insurmountable problem.[15–18]

In each case, a local outer limit has been reached, with dangerous implications for populations in the Third World. A potentially even more serious transgression of local outer limits has occurred as a side effect of reducing the malaria eradication effort to mere insecticide spraying: there is increasing evidence that the intradomiciliary spraying of organochlorine insecticides has resulted in the rapid accumulation of DDT,

BHC, heptachtor and other dangerous compounds in human milk. It has reached quantities of more than twelve parts per million in rural areas of Guatemala, which is over four hundred times greater than the maximum 'acceptable daily intake' limit for human infants. Coupled with protein malnutrition (which is known to increase drastically the toxicity of insecticides in animal experiments) this new danger threatens to wipe out any benefits which may have accrued to populations in target areas subjected to insecticide-based malaria eradication.[19]

It is now realized that malaria cannot be eradicated using the narrow, paramilitary approach; the conditions favouring transmission have to be changed. These conditions are as much related to the physical environment as to the socio-economic and political condition of a population. The boundaries of malaria correspond rather closely with those of the Third World. Where malaria has disappeared, it has been largely due to an improved relationship between man and his environment that is no longer conducive to the transmission of malaria. For example, better housing (including the use of window screens) can lead to successful interruption of parasite transmission by mosquitoes. A national policy leading to well-distributed development at the grass-roots level may be far more effective for eliminating the scourge of malaria than any medico-military war on this disease. The masses could be mobilized to participate in habitat management and biological control schemes to wipe out the breeding grounds or bring down the larval populations of vector species, and to improve their housing. Some recent experience by researchers of the Centre for Endogenous Development Studies in western Iran tends to confirm the utility of the habitat management approach.

Schistosomiasis control is another illustrative case. This snail-borne blood fluke has replaced malaria in Africa as the main vector-borne public health problem, and is also a major threat in Asia and Latin America. This is due to recent tremendous increases in its incidence caused by the implementation of ill-planned water resource schemes, in such works as irrigation canals and dams, which provide a more suitable habitat for snail vectors of this debilitating disease.

In the Nile delta, for example, what was a relatively minor disease

affecting no more than a small segment of the population has now reached very high rates, often up to 75 or even 100 per cent. The Aswan High Dam, while producing some economic gains by providing electricity and permanent irrigation, has at the same time had a tremendous cost in morbidity and mortality due to schistosomiasis.[20] The present approach advocated by WHO is not too different from that described for malaria. It usually consists of chemical warfare against the snails or drug treatment of infected persons. The molluscicides (such as copper sulphate and Baylucide), besides having undesirable side effects on fish and other aquatic organisms, have failed to give effective control of the disease. *Bulinus* snails, for example, have proved to be prolific and effective enemies. The medical approach, too, based usually on antimony compounds to kill the worms in the human blood, has had severe side effects, so severe that they have resulted in hundreds of deaths per year. A widely hailed drug known as hycanthone was shown recently to be potentially carcinogenic, in addition to producing resistance in schistosomes.[21, 22] Thus all attempts at eradicating this disease have come to a dead end. The local outer limits have been reached in many countries. Headed by physicians with narrow training and following a simplistic, non-developmental approach, the schistosomiasis control programmes aided by WHO in most countries have, unfortunately, closely followed the abortive path of malaria eradication, in spite of best intentions.

Meanwhile the only country which has been able successfully to bring this terrible disease under control is China, where the population was mobilized in vast, integrated programmes of health education, habitat management and snail collection and disposal. Very little use has been made of chemicals in the Chinese programme;[23] schistosomiasis control, rather, has formed one integral part of development as a whole.

Water development schemes have violated local outer limits in other ways as well. The Kariba Dam in Zambia is a case in point. Its completion in 1963 displaced close to 60,000 people who lived in the river basin. Their agricultural system was destroyed by the loss of land and fluctuations in the level of run-off water from the dam. An epidemic of sleeping sickness occurred, caused by the more favourable habitat for tsetse flies around the artificial lake. The disease reduced the cattle populations in

some places to less than one-half their former numbers.[24] The example of Kariba Dam is a revealing one, for here a simultaneous transgression of both local inner and outer limits took place. The inner limits were the population's former minimum livelihood, and the outer limits were the degree of resistance of cattle to sleeping sickness.

The main reason behind the construction of the dam had been to provide cheap hydroelectric energy for the foreign copper companies in Zambia and Zimbabwe (the former Northern and Southern Rhodesia). The welfare of the people directly affected—those who lived in the basin of the Zambezi River—was barely considered. Having become newly independent, and being under great pressure from international copper companies, Zambia was unable to resist the pressure and the temptation to have a huge, prestigious project at its doorstep.

In fact attention to large-scale, panacea-like development projects like uni-purpose dams or single-disease eradication campaigns has frequently been the reason for violations of local outer limits.

The ecosocietal approach to development

From the foregoing discussion it can be concluded that concentration on widespread, mass-based solutions would be more appropriate in meeting the local needs (inner limits) of the population, as well as in avoiding the violation of local ecological imperatives and the natural carrying capacities (the outer limits) of a socio-ecological region. Orienting national development planning towards a policy of redistribution would also hasten the achievement of the inner limits—the basic needs of the population—a goal without which no development policy can be worthy of its name.

The history of famines and food policies in India demonstrates amply how redistribution can be more important in meeting the inner limits than increased production. During the worst famines in India there has always been enough food. However, it has not been distributed to those who needed it.[25, 26] As long as a redistributive policy is not implemented—which would be indicative of the existence of social justice—increased production of food and other necessities will only make the rich

richer and the well-fed even better-fed. The poor will still remain hungry.

The conclusion seems almost self-evident: that an unjust social system is incapable of meeting the basic needs of all the people. Yet many efforts at development in countries where social injustice, class privilege and inequitable distribution of wealth are dominant, ignore this fundamental relationship between the social system and the distribution of environmental resources.

Post-war development policies in most Third World countries have, first, increased the gap between the poor and rich segments of the population (the 'two nations' within a developing country), contrary to the redistributive principle in development and making it more difficult to meet the basic needs of the population. Second, these policies in violating the outer limits have usually caused an unfavourable balance of nature, environmental degradation and weakened carrying capacities in local socio-ecological systems. It can be seen therefore that in many Third World countries development policies have actually caused a net underdevelopment at the mass level, as judged by our two main criteria for development.

We must therefore distinguish between *growth* and *development*. Classical development policies have mistaken growth indices (such as per capita income, gross national product, capital accumulation, etc) for indices of development, which, as we have seen, should include the redistribution factor and that of environmental improvement. Most of the time we have had to make do with growth *without* development.

One corollary is that in a socio-ecological system where resources are limited or the outer limits have been violated (the case of most poor countries) it is even more urgent to start with redistribution of resources (which is an indicator of development) rather than with increased production through sophisticated technology (which is only a means of achieving growth). Only after sufficient redistribution has brought the population closer to its inner limits does it become necessary to take advantage of the margin between the inner and outer limits by means of intensifying production.

In this connexion it should also be pointed out that the correct approach to development, which we might call the *ecosocietal approach* or the *redistributive-environmental strategy*,* would make it irrelevant to discuss vague concepts of 'limits to growth',[27] usually based on computer models and theoretical calculations of global outer limits. While recognizing the fact that certain global ecological relationships (eg the nitrogen cycle or the carbon cycle) may ultimately be violated, in terms of the Third World these are mere abstractions. Local outer limits are seen to be far more significant, for they have an immediate bearing on the lives and well-being of the majority of the population.

* Corresponding to UNEP's *ecodevelopment*, a promising sign of progress in this direction, the 'ecosocietal' or redistributive-environmental' approach represents a conscious attempt to make use of environmentally appropriate technologies (eco-techniques) in need-oriented development strategies.

There is an enormous challenge to reorient the path of development towards the ecosocietal approach, in which redistribution of resources and improvement of environmental quality for the masses are the guiding principles. Only thus will we succeed in meeting the basic needs of populations without violating the outer limits of local socio-ecological systems.

References

1 *Declaration on the Third World and the Human Environment*, issued by the independent forty-one-nation Conference on Problems of the Third World and the Human Environment, sponsored by Oi Committee International in parallel with the United Nations Conference on the Human Environment in Stockholm, 4–16 June 1972.
2 'The Cocoyoc Declaration', *Development Dialogue* (Uppsala, The Dag Hammarskjöld Foundation), 1974 (No. 2).
3 For some of the material in this paper I have relied on my earlier publication: 'Is There an Environmental Crisis in the Third World?', *University Quarterly—Higher Education and Society*, (London), Vol. 27, No. 3, summer 1973.
4 T Boza-Barducci, 'Ecological Consequences of Pesticides Used for the Control of Cotton Insects in Cañete Valley, Peru'. In: M T Farvar and J P Milton (eds.), *The Careless Technology—Ecology and International Development*, New York. N.Y., Natural History Press, 1972. *The Careless Technology* contains a collection of many case studies of the violation of ecological outer limits in the Third World.
5 R F Smith and H T Reynolds, 'Effects of Manipulation of Cotton Agroecosystems on Insect Populations'. In Farvar and Milton, op. cit.
6 P L Adkisson, 'A Systems Approach to Cotton Insect Control', *Proceedings of the Beltwide Cotton Production-Mechanization Conference (Houston, Texas)*. Memphis, Tenn., National Cotton Council of America, 1970.

7 G R Conway, 'Ecological Aspects of Pest Control in Malaysia'. In Farvar and Milton, op. cit.

8 Reported in the *Washington Evening Star,* May 1972. The World Health Organization and the Iraqi Government have since undertaken an in-depth analysis of the events in this mass-poisoning event.

9 Lester R Brown, *Seeds of Change: The Green Revolution and Development in the 1970's,* New York, N.Y., Praeger, 1970. See also L R Brown, 'The Social Impact of the Green Revolution', *International Conciliation* (New York, Carnegie Endowment for International Peace), No. 581, January 1971. Lester Brown is one of the main proponents of the 'green revolution'. For an alternative point of view on the social effects, see Harry M Cleaver Jr, 'The Contradictions of the Green Revolution', *Monthly Review,* June 1972.

10 M T Farvar, 'Green Revolutions: Ecological Determinants of Economic Development' (paper presented at the Williams College Conference on Economic Development and Environmental Problems, Williamstown, Mass., September 1970). This paper covers the ecological outer limits violated by the green revolution approach to agricultural development.

11 Mary McNeil, 'Lateritic Soils in Distinct Tropical Environments: Southern Sudan and Brazil'. In Farvar and Milton, op. cit.

12 Allen Young, 'Ecology and Development in Brazil', *Win Magazine,* August 1972.

13 M T Farvar, *Ecological Implications of Insect Control in Central America: Agriculture, Public Health and Development,* Ann Arbor, Mich., University Microfilms, 1972.

14 F Baeza, D Banerji, V Djukanovic, H J Geiger, O Gish, M T Farvar, M Rahnema and G Sterky, *Alternatives in Health—an Ecosocietal Approach.* Report of an expert panel for the 1975 Dag Hammarskjöld Project on Development and International Cooperation. Uppsala, The Dag Hammarskjöld Foundation, April 1975.

15 Filiberto Malagon, 'Mexico's Malaria Problem', *Environment and Underdevelopment: Third World Perspectives (Proceedings of the AAAS Conference on Environmental Sciences and International Development).* In press.

16 Wasif Ahmed, 'Malaria Eradication Problems in South Asia'. In *Environment and Underdevelopment . . .,* op. cit.

17 M T Farvar, *Ecological Implications of Insect Control in Central America . . .,* op. cit. (see note 13 above).

18 D Banerji, 'Social and Cultural Foundations of Health Services Systems', *Economic and Political Weekly* (New Delhi), special number, August 1974.

19 M T Farvar, M Winter and M L Thomas, 'Pesticides in Developing Countries—the Significance of Chlorinated Hydrocarbon Residue in Human Milk from Latin America', *Proceedings of the International Conference on Environmental Monitoring and Sensing (Las Vegas, September 1975),* Las Vegas, Nev., United States Environmental Protection Agency. In press.

20 H van der Schalie, 'World Health Organization Project Egypt 10: A Case History of a Schistosomiasis Control Project'. In Farvar and Milton, op. cit.
21 P E Hartman, K Levine, Z Hartman and H Berger, 'Hycanthone: a Frameshift Mutagen', *Science,* No. 172, 1971, pp. 1058–60.
22 S H Rogers and E Breeding, 'Hycanthone Resistance: Development in *Schistosoma mansoni*', *Science,* No. 172, 1971, pp. 1057–8.
23 T H Cheng, 'Schistosomiasis in Mainland China: A Review of Research and Control Programs since 1949', *American Journal of Tropical Medicine and Hygiene,* Vol. 20, No. 1.
24 T Scudder, 'Ecological Bottlenecks and the Development of the Kariba Lake Basin'. In Farvar and Milton, op. cit.
25 B M Bhatia, *Famines in India: A Study in Some Aspects of the Economic History of India (1860–1965),* New York, N.Y., Asia Publishing House, 1967.
26 B M Bhatia, *India's Food Problems and Policy Since Independence,* Bombay, Somaiya Publications, 1970.
27 D H and D L Meadows, J Randers and W W Behrens III, *The Limits to Growth* (a report for the Club of Rome's Project on the Predicament of Mankind), New York, N.Y., Universe Books, 1972. This pseudo-ecological approach reaches a dangerous height in E R D Goldsmith *et al., A Blueprint for Survival,* special issue of *The Ecologist,* January 1972.

3 Developing the Methodology

A Methodological Approach for Estimating Outer Limits: the Example of Energy Production

by Joseph C Perkowski

Introduction

The schema (Figure 1) depicting value determinations in human needs strategies presented in the paper by W H Matthews in Part 1 (see page 30 above) is a useful illustration of the nature of the conceptual process of 'meeting basic human needs without transgressing outer limits'. This representation should be of interest to planners and decision-makers who wish to anticipate the influence of considerations about outer limits on alternative development strategies. The degree to which this process can be made operational, especially with respect to the choices among values, will be determined only through actual experience in the development field. However, this paper will discuss the technical application of this approach in a general sense for an important aspect of development strategy—energy production—for the purposes of illustration. In the process of this discussion, important substantive questions about the process of development strategy planning in the context of outer limits will be considered, and an initial attempt at constructing illustrative worksheets for quantitative approaches to the problem will be made.

For this analysis the following major questions, among others, will have to be treated:

1 How does the planner construct a hierarchy for analysis of development options?
2 How can a finite list of alternatives be constructed that is neither too limited nor too expansive?
3 What is a finite list of resources and environmental systems to consider which have important implications for outer limits?
4 How 'regressive' should our accounting be of the resource and environmental costs of the system being considered?
5 What information is available on resources and environmental 'inventories' within a given society?

The availability of energy is a prime requirement for any physical development strategy in today's world. Energy in its various forms provides the basis for heavy industry, manufacturing processes, transportation, the expansion of services such as communication in the social infrastructure, and the means to extract and fabricate raw materials into useful products. The development of the energy industries themselves

requires significant use of energy. Energy fuels are diverse by nature and can be utilized in diverse ways.

Initial considerations regarding energy use and the development process must include some examination of the means by which energy is produced and the ways in which such energy is intended for use. The first question to ask involves the desired form of energy use. Shall direct use of fuels be encouraged, or shall electricity production be stressed? Since the conversion of fuel into electricity is an inherently inefficient process, and the transmission of electricity over long distances may be often more costly than shipping fuel directly (including the necessary development of supporting infrastructure), energy as electricity may not play a predominant role in the energy economy of an emerging nation. On the other hand, growing urbanization and the extremely high versatility of electricity as an energy form for certain industries and services means that in many cases electricity use will be important to national development. Some degree of electricity production can be envisaged for almost any society.

Constructing a hierarchy to analyse development options

The question of the type of electricity production systems to be developed—the size and location of the power-plants—provides an example of the first major question in the whole conceptual process. How does the planner construct a choice hierarchy for analysis? How should the analyst move from considering alternative *strategies* (large-scale development plans) in this area, to the consideration of alternative *programmes* (our arbitrary definition of the component subsets of strategies), to considering alternative *projects* within a given programme? To illustrate for this case, alternative strategies for electricity production in a given country could include, among others: (a) numerous hydroelectric plants, providing stable water supply and recreation opportunities as well as electricity, assuming adequate river capacity is available; (b) large numbers of combustion engine generators employed throughout the countryside in villages and farmlands, operated with diesel fuel or gasoline, with local distribution of electricity; (c) a relatively small number of very large central-station power-plants, using fossil fuels or nuclear energy; (d) innovative use of new technologies on a decentralized basis, such as

solar power, fuel cells or wind power; (e) a combination of any or all of the above strategies, with central-station power for large urban areas and small power sources for rural communities.

The last option in this list probably is representative of the mixed nature of electric power development strategies in many developing countries. Let us assume that the strategy which is chosen for electric power development includes some contribution by large-scale central-station power. The hierarchy of planning considerations now leads to consideration of the types of programmes possible under this strategy decision. The options available require electricity production using fuels that have to be obtained and refined before they are brought to the power-plant, thus one is dealing with a choice of programme development for one or more 'fuel cycle' options. The list of these options for the purposes of this example is as follows: (a) the coal fuel cycle; (b) the petroleum fuel cycle; (c) the uranium fuel cycle; (d) the fuel cycle using natural gas.

Drawing up a finite list of alternatives

By posing these alternatives as an arbitrary list, the second major question, how to delineate a finite list of alternatives, is answered. In this case, the list of alternatives is limited by the practical reality of current available technical options. For this example, the focus will be on this level of programme options and their implications when 'outer limits' are considered.

It is relatively convenient to analyse these programme options because, since they are of the same aggregated nature and are proposed to meet the same basic requirement, they can be compared through a process of comparing the similar components of each fuel cycle. The division of each programme option (in this case, each fuel cycle option) into comparable steps is the type of work that tries to answer our second major question in a different sort of way. There may be a number of ways of comparing programme alternatives—but which way of comparison is the best? The common components of every fuel cycle for electricity production are as follows: (a) extraction of fuel; (b) processing or fabrication of fuel; (c) transportation of fuel; (d) power-plant operation; (e) waste disposal of spent fuel.

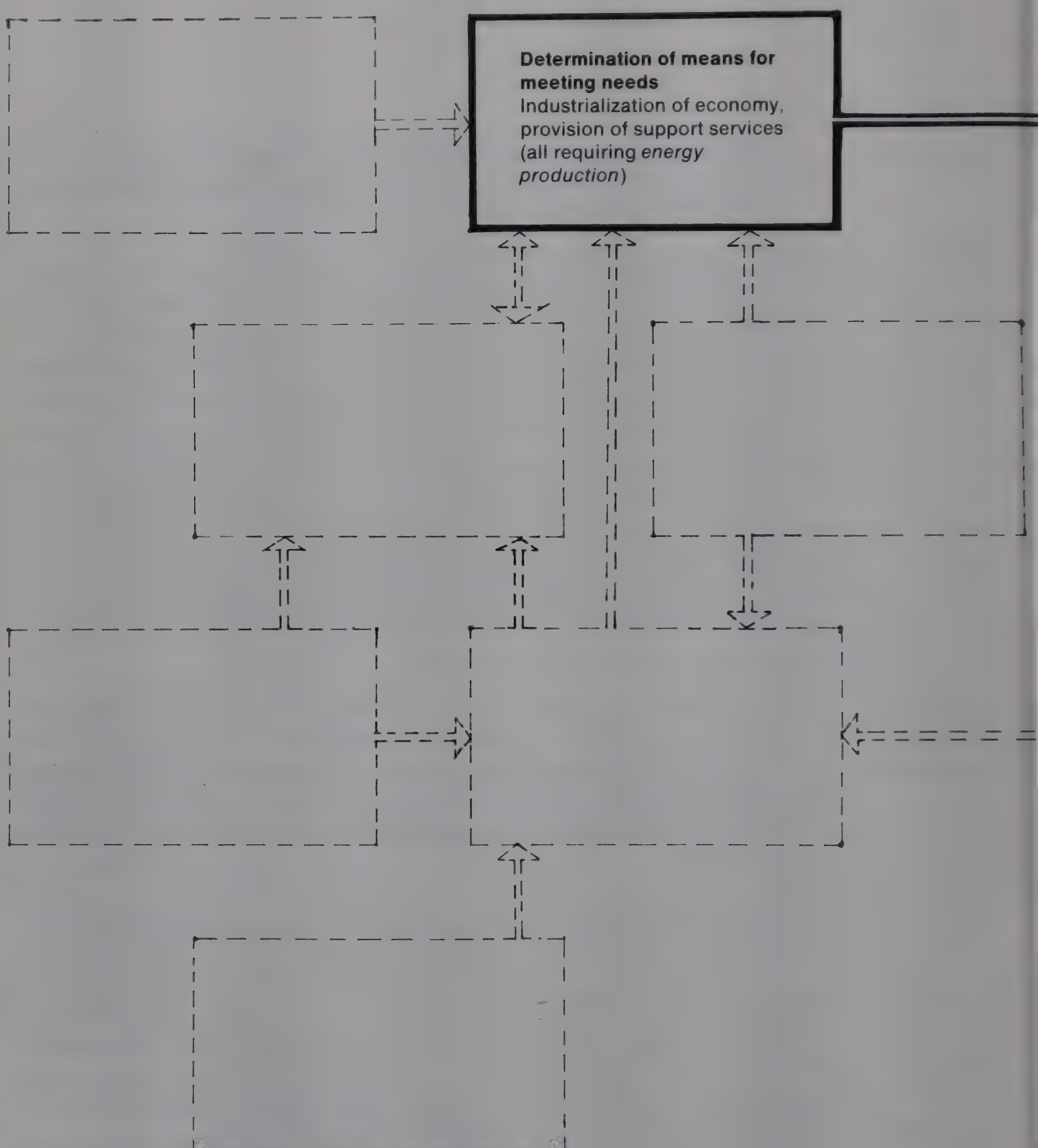
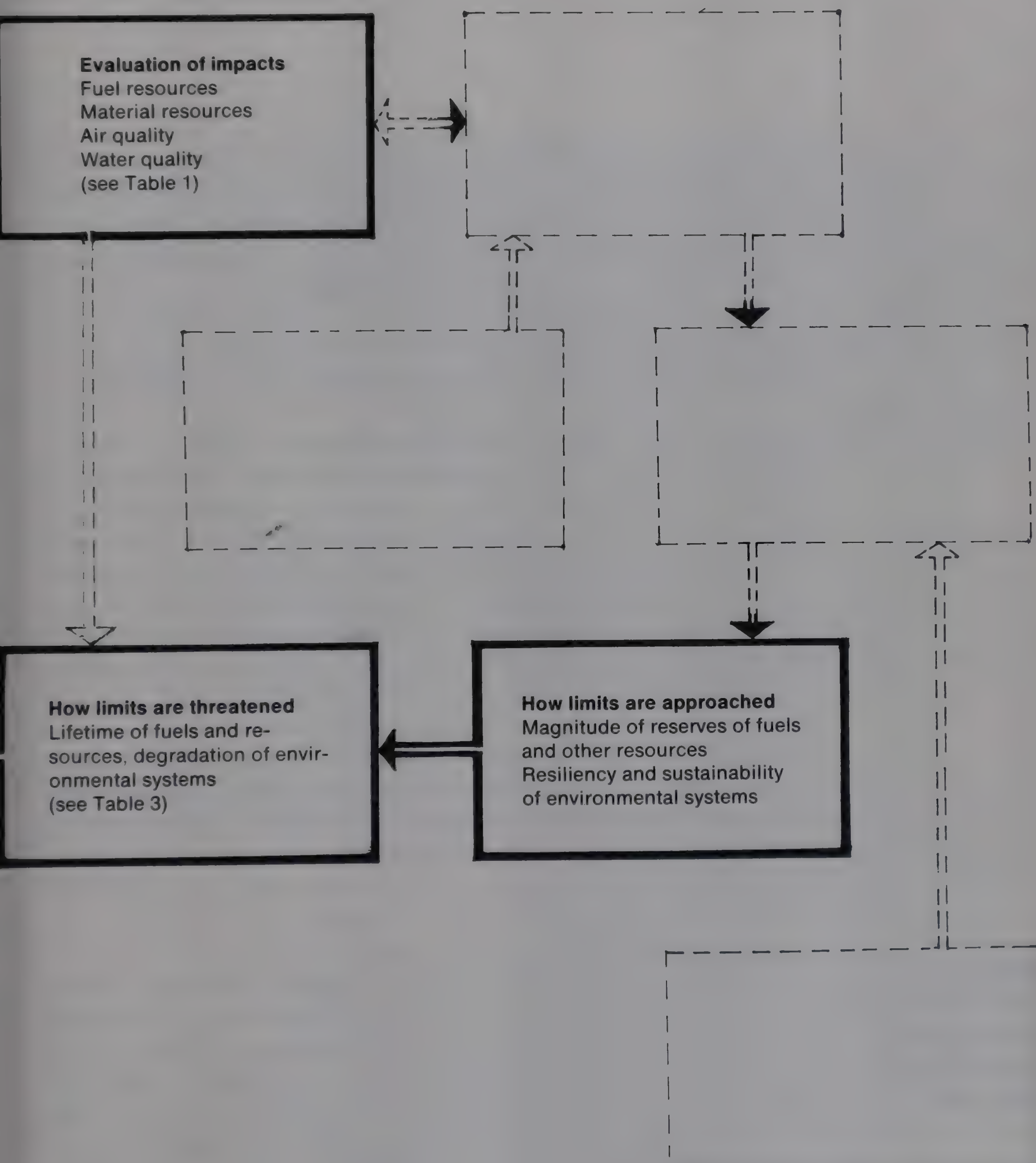


Figure 3 The conceptual process as it relates to the technical evaluation of alternative programmes for the production of electrical energy



The missing steps are shown here by dotted rules: see Figure 1 for a description of each major step in the process.

Note that these components are not options from which we choose the optimal alternative. Rather, each component must be developed in turn in order to construct the entire power-plant programme. The distinction between programmes and projects is now clear, since an individual project, for example an individual fuel-fabrication plant at an individual location, can be evaluated against alternative designs and alternative site locations. But each project is part of a larger programme system, necessary but not sufficient for the effective operation of the programme.

Returning now to the overall conceptual process shown in Figure 1, Figure 3 here develops the concepts of this example as they relate to that part of the overall process which is discussed immediately above. One can now move into an examination of the impacts outer limits on resources and environmental systems can have on a particular programme analysis. The present example is the electrical power-plant system, which has many components in the fuel cycle to support operation of the power-plant. A large-scale power-plant of the order of 1,000 megawatts operating for a period of one year with a 75 per cent load factor (the percentage of time the power-plant actually operates) is a good candidate for study since such a plant provides enough electricity for a US city of approximately 900,000 population. Presumably, urban areas in developing countries may be less wasteful and extravagant in their energy use and therefore a larger number of people could be supported by one of these power-plants.

Listing resources and environmental systems affecting outer limits

The analysis now proceeds to the step on Figure 1 concerned with the determination (evaluation) of impacts on resources and environmental systems. How can the analyst meet this requirement in this case and, more important, for any given programme or development strategy? The first step in answering this question is an attempt to answer the third major question posed in the introduction to this paper—drawing up a list of important resources and environmental systems that can impose physical outer limits. Table 1 is the first draft response to this requirement, composed after serious thought and discussion with various professionals. This table divides resources into categories of 'primary' and 'derived', where 'derived' resources are ones that require the actual in-

volvement of man in order to be produced. The separation of resources into 'derived' (such as, for example, agricultural and chemical products) and 'primary' (fuels, metals and trees, for example) is also a necessary distinction if development options are to be analysed on the basis of inventories of component resources, since much available data will include these items rather than their 'primary' sources. Moreover, substitution of one derived resource for another may not always be possible, making the depletion of a derived resource a potentially important outer limit. The somewhat arbitrary subdivision of environmental systems into six groups is also a result of the experience of the authors in the study of environmental systems.

The nature of the demands on the resources and environmental systems that may be affected (see Table 1) by any alternative plan to develop the facilities for the entire fuel cycle for a programme of electricity production is summarized in the following steps: (1) fuel extraction; (2) processing or fabrication of fuel; (3) transportation of fuel; (4) power-plant operation; (5) waste disposal of spent fuel.

Deciding how regressive our accounting should be

Before actually trying to determine these impacts, one must consider the fourth major question in the process: this is the degree to which our analysis is 'regressive', ie the degree of depth for calculation of impacts for each system component. For example, consider the extraction of underground coal for electricity production in the USA. For the situation of this example, only 57 tons of coal are actually mined for every 100 tons discovered—the remaining 43 tons are 'waste' in the sense that they must remain in the ground, mostly to support the structure of the underground mine. But the energy input into the extractive process itself requires the energy equivalent of almost 1 ton out of the 57 recovered. The refining of 100 barrels of crude oil to produce distillate for power-plant use is a more graphic example. The energy equivalent of 10 barrels of oil is needed for every 97.8 barrels of oil produced (2.2 barrels of oil are 'wasted' in the actual process itself). Where is this energy obtained for refinery operation? It comes from another electricity generator apparatus of some sort, possibly from another power-plant, which in turn has its own resource and environmental impacts. Asking the fourth major question about

Table 1 Lists of example categories of resources and environmental systems

PRIMARY RESOURCES	Examples
Fuels	*Coal, oil, natural gas, nuclear fuels (uranium, thorium, plutonium*[1])
Non-fuel minerals	
Metals	*Aluminium, beryllium, cadmium, chromium, copper, iron, lead, mercury, platinum, tin, tungsten, zinc*
Non-metals	*Clay, fluorspar, glass, salt, sand and gravel, stones, taconite*
Renewable primary resources	*Cotton, freshwater and marine fish, helium,*[2] *land,*[3] *micro-organisms, trees, wool*
Nutrients	Major: *nitrogen,*[2] *phosphorus* Minor: *calcium, iron, magnesium, potassium, sodium, sulphur*

DERIVED RESOURCES	Examples
Food	*Agricultural crops, animal protein, marine aquaculture, freshwater aquaculture, micro-organisms (eg single-cell protein)*
Fuel products	*Electricity, distillate oils (eg gasoline, kerosene), residual oils, hydrocarbon gases*
Mineral-based products	*Cements, ceramics, fertilizers, finished metals*
Petrochemicals and chemical products	*Benzene, inorganic pesticides, inorganic pharmaceuticals, plastics, styrene, sulphuric acid, synthetic polymers*
Renewable resource products	*Cloth, lumber, organic pesticides, organic pharmaceuticals, paper*

1 A special case, because it is an artificial element.
2 Perhaps a special case, since it can be renewed from the atmosphere.
3 Actual physical space used, apart from soil nutrients or representative ecosystems present.

'regressiveness' in analysis is asking how far back we step in the chain of impact analysis. Therefore the five steps in the fuel cycle listed above could include some allowance for these 'regressive' impacts; the more comprehensive they are, the more accurate the analysis.

See pages 94–5 for Table 2

Continuing to the next stage of the conceptual process, Table 2 lists a set of sample impacts (for the coal fuel cycle), essentially a process of providing data for each of the five steps in the fuel cycle in relation to the

ENVIRONMENTAL SYSTEMS

Physical systems		Examples
Air		*Urban air sheds, interaction of air systems with other systems*
Water		
	Freshwater	*Quantity available, hydrologic cycle, biological (and chemical) pollution, physical pollution*
	Marine	*Biological (and chemical) pollution, physical pollution*
Soil[4]		*Exchange capacity (percentage of available and exchangeable nutrients), organic matter (percentage), texture (percentage of sand, silt, clay)*

		Examples
Genetic resources		*Animal genetic resources, micro-organisms, plant genetic resources*
Ecosystem stability[5]		*Community energetics, community structure, life history, nutrient cycling, overall homoeostasis,[6] selection pressure*
Climatic systems		
	Heat	*Heat emitted from all use patterns*
	Atmospheric emissions and dynamic behaviour	*CO_2 particulate and all emissions and their effects on atmospheric balances, especially stratospheric ozone*

4 List of soil types available in E P Odum, *Fundamentals of Ecology* (Philadelphia, W B Saunders, 1971).

5 As discussed on p. 89 of K Watt, *Principles of Environmental Science* (New York, McGraw-Hill, 1973).

6 Should include relationships with other ecosystems.

affected resources and environmental systems. (The reader is cautioned that these data are not taken from a real case and that some of them have been made up simply to provide an illustration of the process and not as a rigorous step in an analysis. Through the use of procedures such as those embodied in Table 2, the analyst can determine with some degree of certainty the impacts of a particular option. The next step in the process involves a calculation of what the total impacts for a given option would be. In this case, line items in a tabulation such as Table 2 would be

Table 2 Sample impacts on resources and environmental systems from a programme of electricity production over th five steps in the fuel cycle (coal)

Resources that may be affected	*Step 1* Fuel extraction[1]	*Step 2* Processing or fabrication of fuel	*Step 3* Transportation of fuel	*Step 4* Power-plant operation	*Step 5* Waste disposal of spent fuel
PRIMARY RESOURCES					
Fuels[2]	*2.4×10^6 tons coal equivalent*[3,4]	*0.5×10^6 tons coal equivalent*[3,4]	*0.05×10^6 tons coal equivalent*[3,4]	*2.5×10^6 tons coal equivalent*[3]	*?*[5]
Non-fuel minerals					
Metals[6]	*Various metals used in extraction industry, plus metals used for steel*	*5 tons various metals,*[7] *plus metals used for steel*	*Presumed negligible*	*10 tons copper, 20 tons iron*[8] *plus metals used for steel*	*?*[9]
Non-metals[6, 7]	*1,000 tons assorted material*[10]	*1,000 tons sand, gravel and clay*	*Negligible*	*5,000 tons sand, gravel, and clay for concrete and other materials*	*100 tons sand and gravel*
Renewable primary resources[11]	*100 acres trees for lumber*[12] *9,000 acres land*[3]	*200 acres land*[3]	*2,200 acres land*[3]	*100 acres trees used for lumber*[12] *700 acres land*[3]	*100 acres land*
Nutrients	*10 tons nitrogen 10 tons phosphorus*[13]	*0*	*0*	*0*	*1 ton nitrogen 1 ton phosphorus*[13]
DERIVED RESOURCES					
Food	*0*[11]	*0*[11]	*0*	*0*[11]	*0*
Fuel products	*Assumed negligible*	*Assumed negligible*	*Assumed negligible*	*Assumed negligible*	*Assumed negligible*
Mineral-based products	*50 tons steel and other metals plus nutrient fertilizers*	*200 tons steel and other alloys*[14]	*10 tons steel and other alloys*[15]	*500 tons steel*[8]	*?*[9]
Petrochemicals and chemical products	*Unknown*	*Unknown*	*Relatively negligible*	*Unknown*	*Relatively negligible*
Renewable resource products	*1,000 tons lumber*	*0*	*1,000 tons lumber*	*0*	*0*

General notes

(a) The data here are in many cases artificially generated. The most generally representative data that were available were used, but no accuracy is claimed for any specific result. The purpose of this study is purely illustrative.

(b) Note that this table provides data only for one particular option (coal). As discussed in the text, the analysis expands rapidly when a comparative judgement must be made of the impacts associated with many options.

Environmental systems that may be affected	Step 1 Fuel extraction[1]	Step 2 Processing or fabrication of fuel	Step 3 Transportation of fuel	Step 4 Power-plant operation	Step 5 Waste disposal of spent fuel
ENVIRONMENTAL SYSTEMS					
Physical systems					
Air	*Unknown but small*[3]	*4,714 tons various pollutants*[3]	*26,270 tons various pollutants from railroads*[3]	*350,000 tons various pollutants*[3]	*Assumed negligible*
Water					
Freshwater	*2,661 tons various pollutants*[3]	*3,853 tons various pollutants*[3]	*Assumed zero*[3]	*813 tons pollutants 10^{13} BTUs of heat*[3]	*Assumed negligible if water-table not disturbed*
Marine[16]	*0*	*0*	*0*	*0*	*0*
Soil	—[17]	*?*[18]	*?*[18]	*Power-plant SO_2 emissions may cause downwind soil acidity*	*?*[18]
Genetic resources	*0*	*0*	*0*	*0*	*0*
Ecosystem stability	—[17]	*?*[19]	*Relatively small*	*?*[19]	*Relatively small*
Climatic systems	*0*	*0*	*0*	*10^{13} BTUs of heat emitted plus various particulate matter and carbon monoxide*[3]	*0*

1 Assume underground coal mining.
2 To include energy input needed for the operation of each process, assume a coal-fuelled electric power-plant provides this energy input which can then be directly added to fuel resource demands.
3 Adapted from: US Council on Environmental Quality, *Energy and the Environment: Electric Power* (Washington, US GPO, 1973).
4 For these items we must add the contributions of petroleum fuels that will be needed to make petrochemicals and chemical products (part of our 'regressive' analysis).
5 The energy requirement needed for disposal of fuel wastes is unknown, but probably negligible compared with the other components of this line item.
6 All the estimates in this category are only unsubstantiated 'educated guesses'.
7 All data are estimated and 'amortized' over expected lifetime of the facility considered.
8 The amount of steel used for structural material is about twice that used to reinforce the concrete foundation, and the total material divided by a 40-year plant lifetime is approximately 500 tons. Copper and iron alloys that include many other metal resources are used in significant amounts (data consists of gross estimates).
9 Not known but probably negligible relative to other line item components.
10 Presumably this is used to help dispose of solid wastes accumulated from the mine excavation process.
11 Freshwater fish as a food source may be depleted because of possible physical and/or thermal pollution.
12 Artificial data.
13 Presumably to assist in land reclamation from waste disposal (artificial data).
14 'Amortized' over an expected 40-year lifetime of a processing plant (artificial data).
15 Estimated metal content of railroad cars, 'amortized' over the expected lifetime of the cars (artificial data).
16 Assume for simplicity that the fuel cycle does not involve any site locations or operations in the coastal environment.
17 Acid drainage from deep mines may severely effect some soils both in terms of soil quality degradation and in terms of the functioning of ecosystems of which soils are an important part.
18 Proper site location may mitigate significant soil impacts.
19 Severe ecosystem disruption may occur in any or all of air, water and soil media, depending on site location, the nature of the receiving air and water media, and the specific nature and effects of the individual pollutant emissions.

combined horizontally for each impact type. Numerous problems arise in the availability and perception of useful information when total impacts are compared to available knowledge about physical outer limits.

Using the available data on resources and environmental systems

The fifth major question, regarding information on resources inventories, poses part of the problem in terms of asking what work is already finished and available that indicates where resources exist and the extent to which these resources have been depleted or degraded. Very few countries have invested the necessary research effort for determining accurate resource reserve data and extraction rate data, and the information that is available may not be readily accessible or may be under some proprietary restrictions.

How can such a vague and restricted information base be compared to a reasonably well-known set of detailed impacts of a specific programme such as a coal fuel cycle for electricity production? Four very basic obstacles confront the analyst immediately: the lack of any information at all on certain particular parameters such as specific effects of certain physical pollutants; the degree of uncertainty of much of the known information; the difficulties in aggregating over geographical boundaries; and the difficulties of studying dynamic effects at different stages in programme or project operation. Table 3 displays a format for the comparison that could be made by the analyst with sufficient information.

See pages 98–9 for Table 3

No attempt has been made to complete fully the degree-of-impact column of Table 3 with specific detail for the example of the coal–electric power fuel cycle. This is not reasonable within the limited compass available for developing this example, for all of the reasons cited in the previous paragraph and for the additional reason that one must also determine which global or regional outer limits will be chosen in the analysis of the impacts. However, comparing the impact data of Table 2 in a general way with the framework of Table 3, we can make some qualitative judgements both of the more prominent limits that may be encountered (as cited in the examples in the degree-of-impact column of Table 3) and of the more critical value conflicts that could occur as a result of this comparison of impacts with potential outer limits. These

values as represented in the conceptual process of Figure 1 could be derived from such a comparison and could result in possible conflict with other value sets over either or both the nature of basic human needs and/or the precise means by which those needs are to be met.

See pages 100–1 for Figure 4

Figure 4 suggests some examples of the types of value-laden conflicts for the example of coal-electricity systems within the conceptual framework of Figure 1. Such conflicts can arise over any proposal for a new development strategy or development programme, or even over a proposal to continue current activities in the light of a revised outer limits analysis which could change the data in Table 3. The outcome may take one of three possible forms: (a) the proposed activity can be adopted unchanged; (b) the proposed activity can be categorically abandoned; (c) an alternative strategy or programme can be developed that either slightly alters or drastically changes the nature of the original proposal.

In this case, for example, the possible outer limit due to depletion of coal reserves may be judged to be of such importance that the coal fuel cycle as a programme alternative is rejected. But the values that lie as the basis for a development strategy emphasizing energy production, such as the wish to 'modernize' society by establishing a strong domestic heavy industry, may still be predominant. Therefore the alternative programme of developing the nuclear fuel cycle for producing electricity is chosen. However, an examination of this fuel cycle through impact assessment techniques such as the methodology of Table 2 indicates, among other things, that while coal-reserve depletion has ceased, the total quantity of waste heat emitted from the nuclear fuel cycle is somewhat greater (by approximately 50 per cent) than that from the coal fuel cycle. At this point, analysis of data in the format of Table 3 may indicate that a large-scale programme of nuclear electric power production may apply a significant stress through waste heat emissions to climate systems. Since neither the coal nor the nuclear fuel cycles can avoid this stress (and the same holds true for other fossil fuels that could be used in central-station electric power-plants), the value of maintaining climatic stability against stresses of uncertain but possibly devastating impact may finally outweigh those values of the proponents of large-scale energy production. A new strategy will have to be formulated that could still meet basic human

Table 3 Comparison of impacts with outer limits for resources and environmental systems

Resources affected	Nature of the outer limit	Degree of impact of the activity (examples using Table 2)[1]
PRIMARY RESOURCES		
Fuels	*Depletion of reserves*[2]	*Degree of impact, when added to other uses of coal, on reserves of a small country, over the lifetime of the plant, may be significant*
Non-fuel minerals		
Metals	*Depletion of (reserves plus recycled stock)*	*Degree of impact, when added to other demands for metals, may be significant for a small country*
Non-metals	*Depletion of (reserves plus recycled stock)*	*Degree of impact, when added to other demands for non-metals, may be significant for a small country*
Renewable primary resources	*Depletion of base from which resources are harvested*[3]	*Depletion is probably not significant*
Nutrients	*Depletion of reserves*[4]	*Probably not significant*

Resources affected	Nature of the outer limit	Degree of impact of the activity (examples using Table 2)[1]
DERIVED RESOURCES		
Food	*Depletion and degradation of base from which resources are harvested*	*Negligible*
Fuel products	*Depletion of fuel constituents*[5]	*Probably not significant*
Mineral-based products	*Depletion of mineral constituents*[5]	*May be significant*
Petro-chemicals and chemical products	*Depletion of constituent*[5] *substances*	*Probably not significant*
Renewable resources products	*Depletion of base from which resource constituents are harvested*	*Probably not significant*

1 Note that this is for coal use only; the analysis is obviously more complex when many alternatives must be judged relative to each other.

2 Plutonium is an artificially produced fuel, but is produced from natural uranium, so the total quantity of available natural uranium is a limiting factor.

3 Helium can be fixed from air (a special case), as noted in Table 1.

4 Nitrogen can be fixed from air, as noted in Table 1.

5 The substitution of some materials for others in the production of derived resources may postpone depletion of some derived and primary resources at the expense of others, and must be included in any calculation of 'outer limits'.

Resources affected	Nature of the outer limit	Degree of impact of the activity (examples using Table 2)[1]
ENVIRONMENTAL SYSTEMS		
Physical systems		
Air	*Degradation of related ecosystems*	*Degradation of ecosystems due to interference of toxic air pollutants may be very important*
Water		
Fresh-water	*Quantity available may be depleted; degradation of related eco-systems*[6]	*If a large fraction of available water in river or lake is needed for cooling, freshwater eco-systems may be disrupted. In any case, pollution will occur*
Marine	*Degradation of related ecosystems*	*If plant is located in coastal area, sen-sitive estuarine and coastal ecosystems may be disrupted*
Soil	*Degradation of soil quality; degradation of related eco-systems*	*Some soils may be stressed by mining run-off or fall-out from power-plant emissions*
Genetic resources	*Depletion of total available plant or animal gene pools*	*Probably not significant*
Ecosystem stability	*Ecosystem degradation*	*May be significant for some resources as a result of air, water and soil degradation*
Climatic systems	*Threshold of tolerance for quantity of heat emitted or pollutants emitted from man's activities in relation to natural climatic variability*	*An added stress of unknown but non-zero magnitude is placed on climate systems*

6 Polluted water can always be recycled; desalinization provides an ultimate source of clean water, so in a technical sense water quality should not be treated as an 'outer limit'.

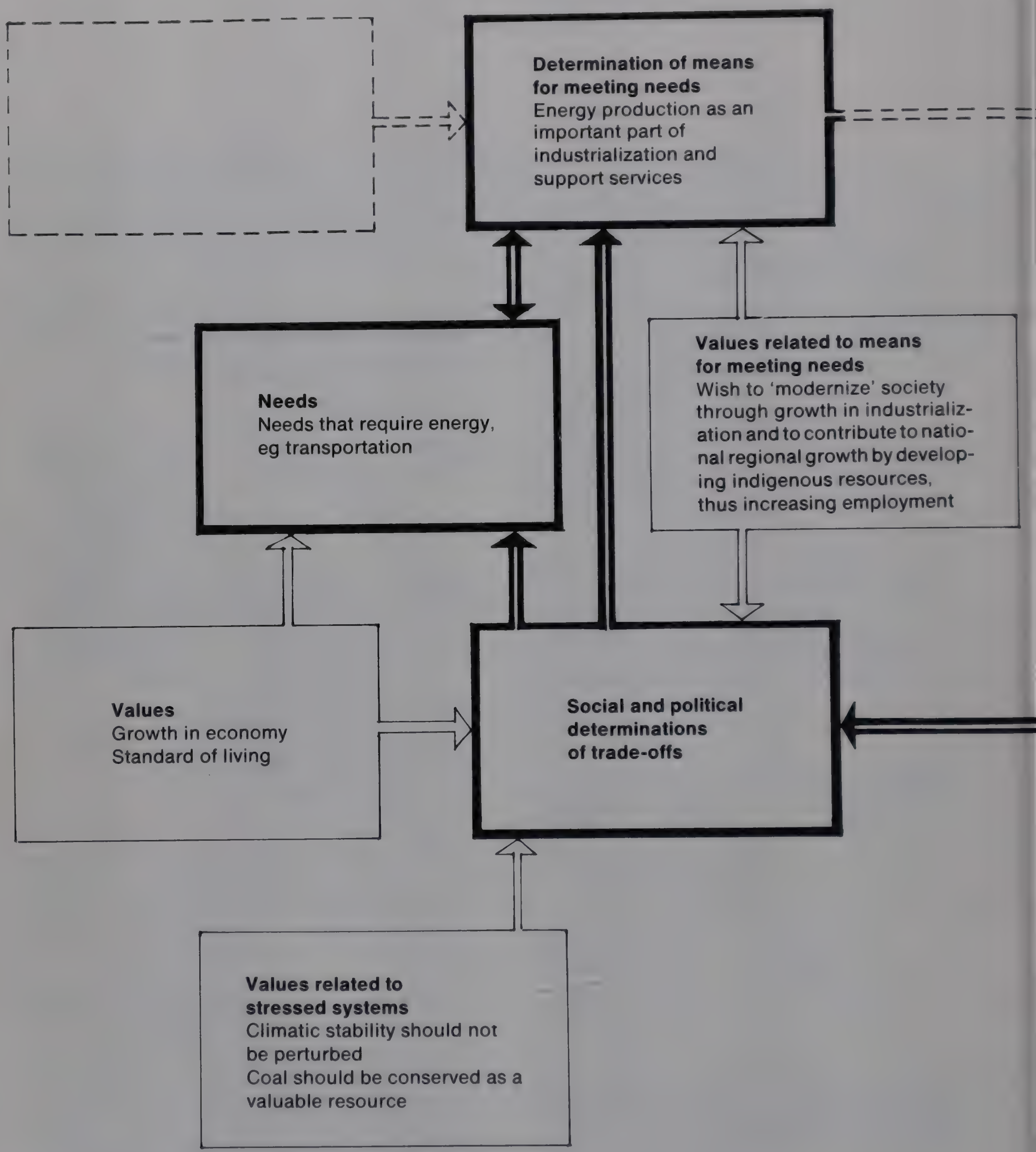
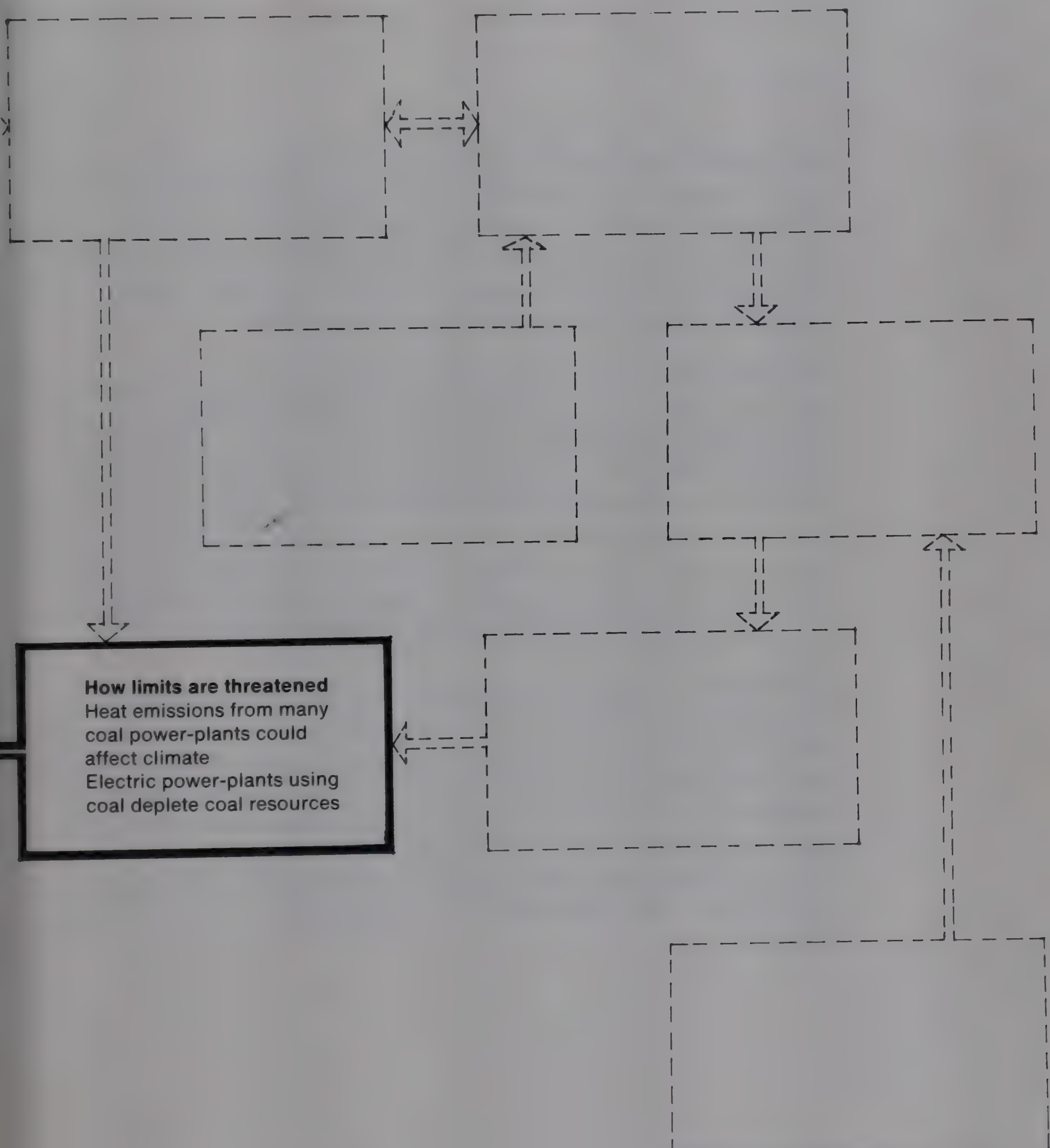


Figure 4 The conceptual process as it relates to the potential value conflicts arising from the evaluation of programme alternatives for the production of electrical energy



The missing steps are shown here by dotted rules: see Figure 1 for a description of each major step in the process.

needs in some way. Perhaps the decentralized location of other types of energy devices, as described in some of the alternative strategies discussed earlier, could be considered. In any event, the conceptual process of Figure 1 can be used again to enable the analyst to understand all the benefits and costs and implications of this alternative development strategy in the light of concerns about physical outer limits.

It is important to note that for a specific country the nature of an outer limit may in some cases include national economic constraints as well as physical ones. For example, the existence of only a small domestic reserve of coal but an adequate reserve of uranium may be the most compelling criterion for a particular choice among programme alternatives for energy development. For the purposes of this example the concerns are centred on the influence of physical outer limits on development strategies and the resultant value-laden criteria that are applied to choosing such strategies for the satisfaction of basic human needs.

It is clear that if development planners are to add the constraint of 'not transgressing outer limits' to their work they must develop some very sophisticated analytical approaches for determining its implications. This paper has explored some of the problems that must be overcome and by considering the example of energy production has illustrated some of the steps that must be taken. This should only be regarded as an initial attempt to develop the methodologies that will be needed. The challenge to formulate a truly operational set of approaches is still very much before us.

The Dag Hammarskjöld Foundation was established in 1962 in memory of the late Secretary General of the United Nations. It organizes seminars and conferences on the social, economic and legal problems of the Third World and publishes the materials arising out of these activities (a list is available on request). In recent years, the foundation has increasingly devoted itself to the promotion of a continuing dialogue on world development among policy-makers, administrators and professionals, in particular in the Third World.

The foundation also publishes, in two issues a year, ***Development Dialogue****, a journal of international development cooperation, copies of which may be obtained free of charge on application to the foundation.*

The Dag Hammarskjöld Foundation
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A publication of the 1975 Dag Hammarskjöld Project

The papers in this volume were contributed to the 1975 Dag Hammarskjöld Project on Development and International Cooperation (*What Now: Another Development*). They address the issues of development strategies and outer limits, as prerequisites in meeting basic human needs. They represent responses to the question, advanced by Maurice F Strong, when executive director of the United Nations Environment Programme, 'Can we meet basic human needs without transgressing resource and environmental outer limits?'

This question, which provided a seminal moment in the genesis of the 1975 Dag Hammarskjöld Project, can be answered only by further questions: Who is to define the needs? Those that have them—or those that have the means to satisfy them? What is really meant by 'outer limits' and what constitutes 'transgression'?

The seeming ease with which these and other related questions might be answered belies the need, in fact, for a very sophisticated understanding of societal and political processes as a precondition to the determination of outer limits. This volume constitutes an introduction to these difficulties and also to the concept of 'ecodevelopment', a way forward to the satisfaction of basic human needs without transgressing local or global outer limits.

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